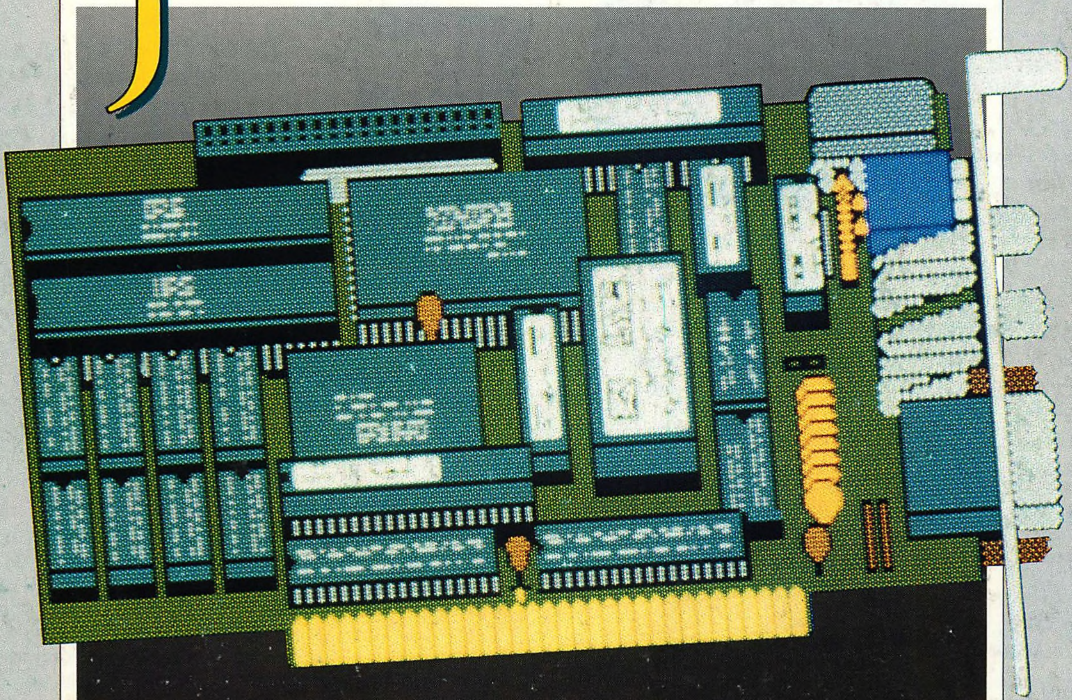
OCTOBER 1986 VOL. 4, NO. 10 $3.95

FOR IBM PERSONAL COMPUTER USERS

PC TECH JOURNAL



EVALUATING THE EGA
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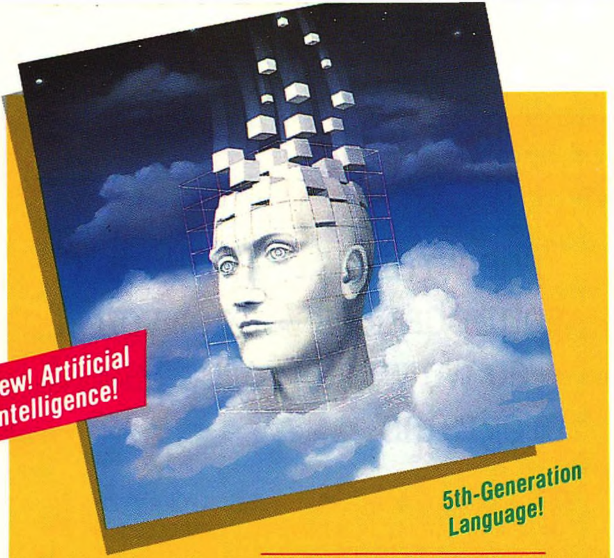


New! Artificial Intelligence!

5th-Generation Language!

Turbo Pascal Programming!

$10.00 Scratch 'n Win Rebate!

Turbo Prolog™

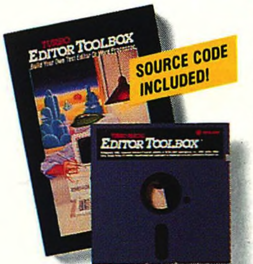
> "If you're at all interested in artificial intelligence, databases, expert systems, or new ways of thinking about programming, by all means plunk down your $100 and buy a copy of Turbo Prolog."
> Bruce Webster, BYTE

"Borland International, Inc. is gunning onto the fast track in the artificial intelligence and engineering-language-software race, riding aboard a new $99 Turbo Prolog," says Tom Schwartz in *Electronic Engineering Times.* And so we are. Our new Turbo Prolog has drawn rave reviews—which we think are well deserved—because Turbo Prolog brings 5th-generation language and supercomputer power to your IBM PC and compatibles. Turbo Prolog is a high-speed compiler for the artificial intelligence language, Prolog, which is probably one of the most powerful programming languages ever conceived. We made a worldwide impact with Turbo Pascal and you can expect the same results and revolution from Turbo Prolog, the natural language of artificial intelligence. Darryl Rubin, writing in *AI Expert* said, *"Turbo Prolog offers generally the fastest and most approachable implementation of Prolog."* Suggested retail, $99.95. Use a $10.00 Scratch 'n Win Rebate and that goes down to only *$89.95!* Minimum memory: 384K.

Technical Specifications:

TURBO PASCAL 3.0 Minimum memory: 128K; includes 8087 and BCD features for 16-bit MS-DOS and CP/M-86 systems. CP/M-80 version minimum memory: 48K; 8087 and BCD features not available. ***TURBO DATABASE TOOLBOX*** Minimum memory: 128K. CP/M-80 minimum memory: 48K. Requires Turbo Pascal 2.0 or later. ***TURBO GRAPHIX TOOLBOX**** Minimum memory: 192K. Requires PC/MS-DOS 2.0 or later, Turbo Pascal 3.0, and IBM CGA, Hercules Monochrome Card or equivalent. ***TURBO TUTOR 2.0*** Minimum memory: 192K. CP/M-80 version minimum memory 48K. Requires PC/MS-DOS 2.0 or later and Turbo Pascal 3.0. ***TURBO EDITOR TOOLBOX**** Minimum memory: 192K. Requires PC/MS-DOS 2.0 or later and Turbo Pascal 3.0. ***TURBO GAMEWORKS**** Minimum memory: 192K. Requires PC/MS-DOS 2.0 or later and Turbo Pascal 3.0. ***TURBO PROLOG**** Minimum memory: 384K. ***REFLEX: THE ANALYST**** Minimum memory: 384K. Requires IBM CGA, Hercules Monochrome Card or equivalent. Works with Intel's AboveBoard-PC and -AT; AST's RAMpage! and RAMpage! AT; Quadram's Liberty-PC and -AT; Tecmar's 640 Plus; IBM's EGA and 3270/PC; AT&T's 6300 and many others. ***REFLEX WORKSHOP**** Minimum memory: 384K. Requires Reflex: The Analyst. ***TURBO LIGHTNING**** Minimum memory: 256K. Two disk drives required. Hard disk recommended. ***LIGHTNING WORD WIZARD**** Minimum memory: 256K. Requires Turbo Lightning. Turbo Pascal 3.0 required to edit source code. ***SIDEKICK**** Minimum memory: 128K. ***TRAVELING SIDEKICK**** Minimum memory: 256K. ***SUPERKEY**** Minimum memory: 128K. *For IBM PC, AT, XT, PCjr and true compatibles only, running PC/MS-DOS 2.0 or later.

Build Your Own Word Processor!



SOURCE CODE INCLUDED!

$10.00 Scratch 'n Win Rebate!

Turbo Editor Toolbox™

Recently released, we called our new Turbo Editor Toolbox a "construction set to write your own word processor." Peter Feldmann of *PC Magazine* covered it pretty well with, *"A 'write your own word processor' program for intermediate level programmers, with lots of help in the form of prewritten procedures covering everything from word wrap to pull-down windows."* Source code is included, and we also include MicroStar, a full-blown text editor with pull-down menus and windowing. It interfaces directly with Turbo Lightning to let you spell-check your MicroStar files. Jerry Pournelle of *BYTE* magazine said, *"The new Turbo Editor Toolbox is the Turbo Pascal source code to just about anything you ever wanted a PC-compatible text editor to do."* Suggested retail: $69.95. Use a $10.00 Scratch 'n Win Rebate and you'll get all this for *only $59.95!* Minimum memory: 192K.

MicroStar file directory accessed by pull-down menu

Borland's Business Productivity Programs:

***Reflex: The Analyst*®** Analytical database manager. Provides complete, new look at data normally hidden by programs like 1-2-3® and dBASE.® Best report generator for, and complement to, 1-2-3.

***Reflex Workshop*™** Important new addition to Reflex: The Analyst. Gives you 22 different templates to run your business right.

***SideKick*®** Complete RAM-resident desktop management includes notepad, dialer, calculator and more.

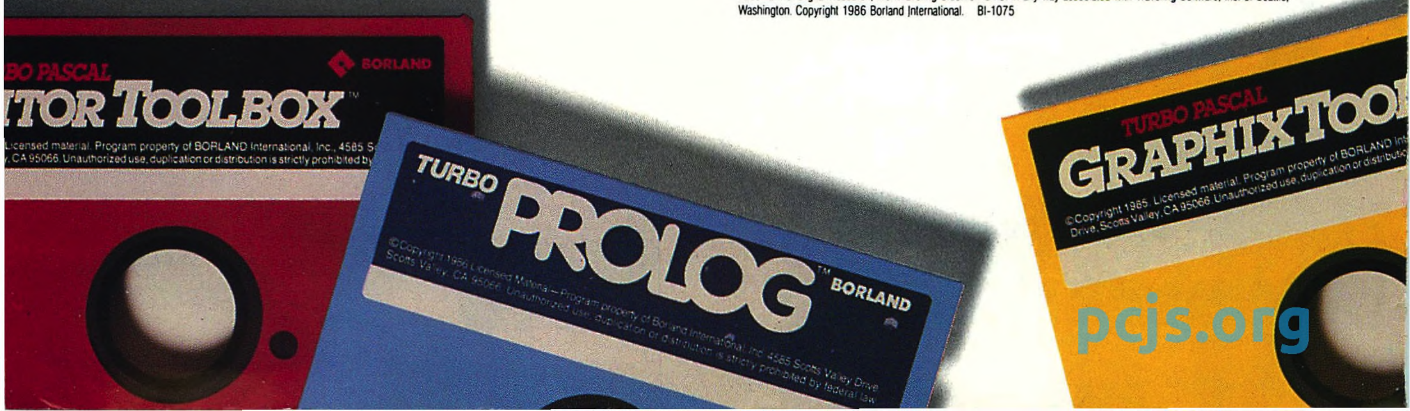
***Traveling SideKick*®** Electronic version of business/personal diaries, daytime organizers; works with your SideKick files; important professional tool.

***SuperKey*®** Keyboard enhancer. Simple macros turn 1000 keystrokes into 1. Also encrypts your files to keep confidential files confidential.

Borland's Electronic Reference Programs:

***Turbo Lightning*®** Works with all your programs and checks your spelling *while you type!* Includes 80,000-word Random House® Concise Word List and 50,000-word Random House Thesaurus. Forerunner of Turbo Lightning Library.™

***Lightning Word Wizard*™** Includes ingenious crossword solver and six other word challenges. If you're into programming, Lightning Word Wizard is also a development toolbox and the technical reference manual for Turbo Lightning.



Turbo Pascal Programming!

Learn Secrets, Strategies, Game Theory!

$10.00 Scratch 'n Win Rebate!

Turbo GameWorks®

Also recently released, Turbo GameWorks is what you think it is: "Games" and "Works." Games you can play right away (like Chess, Bridge and Go-Moku), plus the Works—which is how computer games work. All the secrets and strategies of game theory are there for you to learn. You can play the games "as is" or modify them any which way you want. Source code is included to let you do that, and whether you want to write your own games or simply play the off-the-shelf games, Turbo GameWorks will give hours of diversion, education, and intrigue. George Koltanowski, Dean of American Chess, and former President, United States Chess Federation, reacted to Turbo GameWorks like this: "*With Turbo GameWorks, you're on your way to becoming a master chess player.*" And Kit Woolsey, writer, author, and twice Champion of the Blue Ribbon Pairs, wrote, "*Now play the world's most popular card game—Bridge . . . even program your own bidding and scoring conventions.*" Suggested retail: $69.95. Use a $10.00 Scratch 'n Win Rebate and you're talking an *incredible $59.95!* Minimum memory: 192K.

Turbo GameWorks' Chessboard

Create Your Own High-Res Graphics!

$10.00 Scratch 'n Win Rebate!

Turbo Graphix Toolbox®

It includes a library of graphics routines for Turbo Pascal programs. Lets even beginning programmers create high-resolution graphics with an IBM, Hercules,™ or compatible graphics adapter. Our Turbo Graphix Toolbox includes all the tools you'll ever need for complex business graphics, easy windowing, and storing screen images to memory. It comes complete with source code, ready to compile. Suggested retail: $69.95, but with a $10.00 Scratch 'n Win Rebate, *only $59.95!* Minimum memory: 192K.

The Ultimate Learning Experience!

$10.00 Scratch 'n Win Rebate!

COMPLETELY NEW VERSION!

Turbo Tutor® 2.0

The new Turbo Tutor can take you from "What's a computer?" through complex data structures, assembly languages, trees, tips on writing long programs in Turbo Pascal, and a high level of expertise. Source code for everything is included. New split screens allow you to put source text in the bottom half of the screen and run the examples in the top half. There are quizzes that ask you, show you, tell you, teach you. You get a 400-page manual—which is not as daunting as it sounds, because unlike many software manuals, it was not written by orangutans. Suggested retail: $39.95. Use a $10.00 Scratch 'n Win Rebate and you're down to an *unheard of $29.95!* Minimum memory: 192K.

Recognition for Borland International has come from business, trade, and media, and includes both product awards and awards for technical excellence and marketing.

America's Cup. Coming Soon!

How to use Scratch 'n Win Rebates

It's really simple. You purchase the product between 9/5/86 and 3/31/87, and return the license agreement along with dated proof of purchase and your rebate card. We'll mail you a check for $10.00 on single product purchases or a check for $15.00 when you buy an advertised "bundle"—which means our Turbo Pascal Jumbo Pack, or Turbo Lightning and Lightning Word Wizard, or Reflex: The Analyst and Reflex Workshop, or SideKick and Traveling SideKick. (Restrictions do apply. Rebates are not valid in combination with any other Borland or dealer discount. See Official Rules on back of Instant Winner card).

Send a buck to the boat!

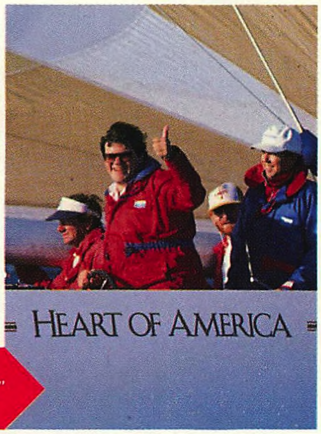
If you'd like to help America's effort to recapture the America's Cup from Australia, you can make a tax-deductible donation to "Heart of America" Challenge, 11 South LaSalle St., Suite 1670, Chicago, Illinois 60603

Sail designs generated from Shore Sails' Turbo Pascal programs.

How Borland is helping bring the America's Cup back to America!

"I think those who grasp the technology will prevail"

Bill Shore, President, Shore Sails Co., Newport, RI



Borland's Philippe Kahn at the helm of America's Cup challenger "Heart of America," with Shore Sails' President Bill Shore

"Sail-making is traditional—a craft—but I think we're huge steps ahead of the competition when we get involved with higher technology," says Shore.

He and Shore Sails' 17 different franchised sail lofts in the U.S. are in what Shore describes as a "highly competitive business, whether it's America's Cup racing or any race." And he adds, "You guys (Borland) do good stuff that's affordable, which is one of the reasons why we wrote all our sail design programs in Turbo Pascal.®"

"These days," he says, "there are many parts to a sail, and Turbo Pascal lets us arrange all the parts properly. We design what the garment industry calls a 'marker'—and rely on Turbo Pascal to do critical things like getting thread lines in the same direction as load lines.

We take the diskette to our new $250,000 laser cutter, which follows the Pascal program precisely, draws out the sail and cuts out the sail. We glue and sew and you've got the best there is."

"Heart of America" surfing downwind, Santa Cruz, California

"The wrong sails will sink your chances—if not your boat—so we wrote Turbo Pascal programs"

Win Fowler, Shore Sails Co., Portland, Maine.

The right sail design, at the right price, right now, has to happen in 17 different Shore Sails Lofts across America.

It had to happen with America's Cup challenger *Heart of America* which carries Shore sails—and it has to happen with the (currently) 700 different boats that Shore Sails has in their Turbo Database Toolbox.™

Sail design, sail pricing and "beating the handicapper" are all done at Shore Sails with Turbo Pascal.

In case you don't know the sharp end from the blunt end of a boat, the right sail design for any boat is more than design and price. It's tactical advantage. Designing sails that take the greatest advantage of the boat's basic design and rigging without getting stuck with a heavier-than-desirable Official Handicap. (Handicaps can eat your chances faster than a Great White.)

The "right sail" design bends but doesn't break the racing rules written by, amongst others, MORR (Midget Offshore Racing Rules) or IOR (International Offshore Rules). Turbo Pascal spills out "right sail" designs for Shore Sails so their customers tend to "handicap" the Rules Committee instead of the other way around.

Shore Sails' connection with Borland doesn't end with Turbo Pascal and our Database Toolbox.

Shore's Fowler has also written SuperKey® macros for "every file we have" and says, "We'd be lost without them."

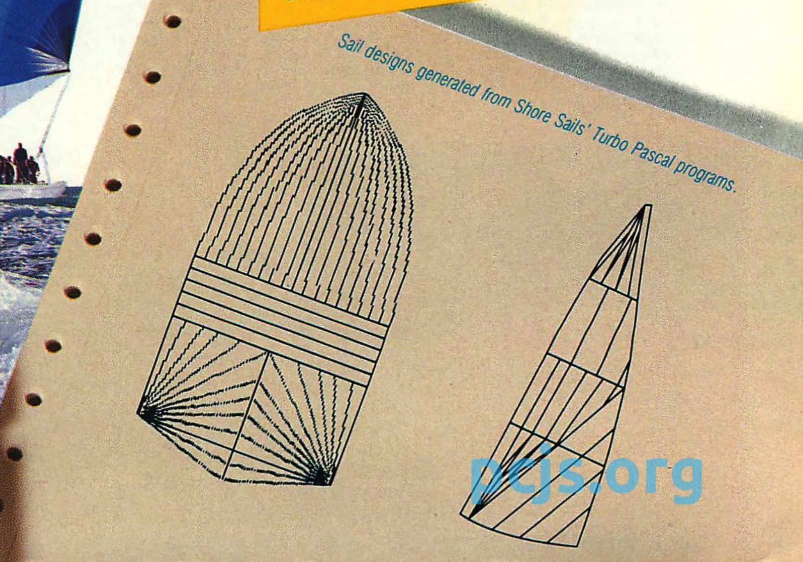
He uses SideKick® to dial every phone call and SideKick's Notepad to communicate between all the Lofts, saying, "That way we don't need a word processor." Shore Sails also uses Turbo Lightning® and Reflex: The Analyst.®

So why so many Borland products in one company?

Win Fowler says, "We'd be sunk without them!"

"There is no second prize" Omar Bradley

Sail designs generated from Shore Sails' Turbo Pascal programs.



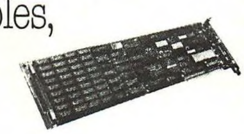
Borland's Instant Winner Game

Scratch this card now and you could *instantly win* 2 free round-trip airline tickets to Australia for the America's Cup Race!

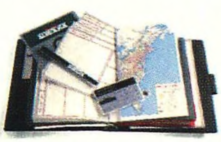
$10,000

First Prize ($10,000 value!) includes accommodations for two in Perth, Australia during the final America's Cup races, which start January 31, 1987. See America win it back after our *only* loss in 134 years! There's more than one *instant winner* in Borland's Instant Winner Game, because you could win one of two new $6,895 4-WD Suzuki Samurai convertibles, or a $4,995 AST TurboLaser™ printer, or a $4,499 Toshiba T3100,™ or a $2,399 Toshiba T1100™ Plus, or a $595 AST SixPakPremium™, or a $69.95 Traveling SideKick,® or any one of hundreds of other Borland products—and at the very least a Borland Rebate Coupon, good for $10 off any single product or $15 off any bundled product offer!

$6,895



$4,499



$69.95

See Official Rules on the back of this card for details.

Don't delay! There will be a second-chance drawing for the trip if not claimed by 12/30/86. There's also a second-chance drawing for the two Suzukis if not claimed by 2/26/87. All rebate coupons are good for products purchased 9/5/86-3/31/87. Product prices above are suggested list prices.

Rub the silver box to reveal whether you win a prize or get a rebate coupon. Then fill in the second-chance entry blank to the right.

Second-Chance Sweepstakes Entry!

We're running two Second-Chance Sweepstakes drawings to award the trip and cars. They *will be won* by someone—it *could be you!* Fill in the entry coupon and mail it now. Winners will be notified immediately, because the final America's Cup races start in Australia on January 31, 1987, and you'll have to pack in a hurry.

(You will need a valid passport and the ability to comprehend Australian versions of the English language.)

Name ____________________

Address ____________________

City ____________________

State ________ Zip ________

OFFICIAL RULES - BORLAND INSTANT WINNER GAME

1. NO PURCHASE NECESSARY: To participate, you may obtain a game card inserted into the October, November, December, or January issue of the following magazines: PC World; Byte; PC Tech Journal; PC Magazine. You may also obtain a game card by mailing a self-addressed, stamped envelope to: Borland International Game Card, P.O. Box 870, Wilton, CT 06897. (Washington State residents send self-addressed envelope.) Limit one game card per stamped request. All requests must be received by January 15, 1987.

2. TO PLAY: Remove the rub-off area on the game card to reveal what prize or rebate offer you have obtained.

3. PRIZES/REBATES: Beneath the rub-off area one of the following prizes may be revealed: Trip for Two to America's Cup Races or S10,000; 1986 Suzuki 4W Samurai Convertible or S6,895; AST Turbo Laser; Toshiba 1100 Portable Computer; Toshiba 3100 Portable Computer; AST Six Pakpremium; AST Advantagepremium; AST 3G Pak; AST Rampage; AST Rampage AT; Free Borland Product, or you may obtain the following rebate offer: S10 rebate offer on any individual product or S15 rebate offer on any single advertised Borland bundle (See rule # 11 for prize details.).

4. PRIZE CLAIMS: If you obtain one of the prizes stated in Rule # 3, sign your full legal signature on the game card and send via certified mail (copy should be made for your records) along with your name and address to: Borland International Prize Claim, 196 Danbury Road, Wilton, CT 06897. All prize claims must be received or postmarked by February 15, 1987. (See Rule # 12 for Trip for Two to America's Cup exception.)

5. REBATE CLAIMS: Rebates are good for products purchased from September 5, 1986 through March 31, 1987. The S10 rebate is good for any individual Borland product and the S15 rebate is good for any advertised Borland software bundle. To receive your rebate you must return your completed license agreement from the manual, this game card and dated proof of purchase to: Borland International, Game Card Rebate, 4585 Scotts Valley Drive, Scotts Valley, CA 95066. Upon receipt of the license agreement, game card and proof of purchase, Borland will send your check. Rebate is not valid with any other rebate or promotion offered directly from Borland.

6. VERIFICATION: All game materials are subject to verification. Game materials are void and will be rejected if not obtained through authorized, legitimate channels, and may be rejected if any part is reproduced, counterfeited, torn or altered in any way, or if materials contain printing, typographical, or mechanical errors. Decisions of the Redemption Center are final. Game pieces from any game other than the Borland Instant Winner Game may not be used in this game.

7. CONDITIONS OF PARTICIPATION: Material submitted becomes the property of Borland International. The submission of game pieces is the sole responsibility of the individual seeking verification, who is solely responsible for lost, late, or misdirected mail. All taxes, registration and inspection fees are the sole responsibility of the verified winner. Winners may be required to execute an affidavit of eligibility and name and likeness publicity release. By participating in the game you accept and agree to be bound by these rules and the decision of the Official Redemption Center which will be final.

8. ELIGIBILITY: Participation is open solely to residents of the United States 18 years of age and over, except employees and agents of Borland International, service agencies, and individuals engaged in the development, production, or distribution of game materials, The Merritt Group, Inc. and their immediate family or members of their households. Void in Vermont and where prohibited by law.

9. GAME SCHEDULE AND AWARD OF PRIZES: The Borland Instant Winner Game will commence on or about September 5, 1986 and end on January 30, 1987. It will officially end, however, when all game pieces are distributed. Verified game prizes will be awarded within thirty (30) days from the date of their receipt for verification at the Official Redemption Center. A major prize winners' list can be obtained by sending a stamped, self-addressed envelope to: Borland Instant Winner Game Winners' List, P.O. Box 7089, Wilton, CT 06897.

10. ODDS CHART: The odds of winning prizes are based upon obtaining the one rare game piece among the applicable number of game pieces.

PRIZE	Qty.	Total Value	Odds of Winning
Trip for Two to America's Cup or $10,000	1	S 10,000.00	1 in 6,458,000
Suzuki 4W Samurai Convertible JA or $6,895	2	S 13,790.00	1 in 3,229,000
AST Turbo Laser	1	S 4,995.00	1 in 6,458,000
Toshiba Portable Computer	2	S 6,898.00	1 in 3,229,000
AST Memory Boards	25	S 15,025.00	1 in 258,320
Borland Products	1,000	S149,000.00	1 in 6,458
OVERALL TOTAL	**1,031**	**$199,708.00**	**1 in 6,264**

All remaining game cards will contain a S10 rebate good on any individual Borland product or a S15 rebate good toward any advertised Borland software bundle.

11. PRIZE DETAILS: Trip for two to America's Cup Races (or S10,000) will include coach seating round trip airfare on regularly scheduled commercial airline from San Francisco, California to Perth, Australia and up to two weeks hotel accommodations in Perth, Australia plus S4,500 spending cash. Winners will be responsible for obtaining visa, passport, and all other travel documents. Trip does not include meals, taxes, excess baggage charges and other hotel charges. Minor must be accompanied by parent or legal guardian.

Suzuki 4W Samurai Convertible JA Standard Equipment Package (or S6,895), verified winner will be responsible for all registration, insurance, and licensing fees. AST Turbo Laser; Toshiba Portable Computer Model # T1100; Toshiba Portable Computer Model # T3100; AST Memory Boards and Free Borland Products are non-substitutional except by sponsor due to product availability and all warranties and guarantees are subject to manufacturers terms. All prizes are non-transferrable. Winning consumer is responsible for all local, state and federal taxes.

12. SECOND CHANCE SWEEPSTAKES: There are two Second Chance Sweepstakes drawings scheduled to be conducted on December 31, 1986 and February 28, 1987. Random drawing from all entries received by December 30, 1986 will award trip for two to America's Cup Races (or S10,000). Random drawing from all entries received by February 26, 1987 will award two (2) Suzuki 4W Samurai (or S6,895). All remaining prizes that are unclaimed after February 15, 1987 will remain unclaimed.

If you have any questions concerning the Borland Instant Winner Game, call: 1-800-451-4471.

Turbo Pascal Programming!

$10.00 Scratch 'n Win Rebate!

Turbo Pascal® 3.0

"For the IBM® PC, the benchmark Pascal compiler is undoubtedly Borland International's Turbo Pascal," says Gary Ray of *PC Week*. We and more than 500,000 other people around the world think Mr. Ray got that right. Since launch, Turbo Pascal has become the *de facto* worldwide standard in high-speed Pascal compilers. Described by Jeff Duntemann of *PC Magazine* as the *"Language deal of the century,"* Turbo Pascal is now an even better deal than that—because we've *included* the most popular options (BCD reals and 8087 support). What used

Turbo Pascal now includes free 8087 support and BCD!

to cost $124.95 is now only $99.95! You now get a lot more for a lot less: the compiler, a completely integrated programming environment, and BCD reals and 8087 support—all for a suggested retail of only $99.95. And with a Scratch 'n Win $10.00 Rebate, you pay *only $89.95*—which really is the "language deal of the century"! Minimum memory: 128K.

$10.00 Scratch 'n Win Rebate!

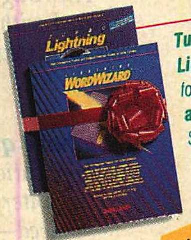
Turbo Database Toolbox™

A perfect complement to Turbo Pascal, because it contains a complete library of Pascal procedures that allows you to search and sort data and build powerful database applications. Having Turbo Database Toolbox means you don't have to re-invent the wheel each time you write a Turbo Pascal program. It comes with source code for a free sample database—right on disk. The database can be searched by key words or numbers. Update, add, or delete records as needed. Just compile it and it's ready to go to work for you. (Shore Sails has more than 700 boat designs and rigs in their Database Toolbox. See front page story.) Suggested retail: $69.95. With a $10.00 Scratch 'n Win Rebate check back from us, *only $59.95!* Minimum memory: 128K.

Build Your Own Database Applications!

SPECIAL PRICES! AMAZING VALUE! ACT NOW!

It's the Works! Everything! The whole electronic enchilada! It's the **Jumbo Pack . . . Turbo Pascal 3.0, Turbo Tutor 2.0, Turbo Editor, Turbo GameWorks, Turbo Graphix and Turbo Database.** All 6 Turbo Pascal programs for only $299.00—or **only $284.00** with a $15.00 Scratch 'n Win Rebate! That's about $47.00 each and that's a deal!



Turbo Lightning and **Lightning Word Wizard** for only $149.95! and an **amazing $134.95** after a $15.00 Scratch 'n Win Rebate!

$15.00 Scratch 'n Win Rebate on all Xmas packs!

Save a bundle on our bundles!

SideKick and **Traveling SideKick** for only $125.00 but **only $110.00** after a $15.00 Scratch 'n Win Rebate!

Reflex: The Analyst and the new **Reflex Workshop** for only $199.95! And a $15.00 Scratch 'n Win Rebate cuts that down to **only $184.95!**

BORLAND INTERNATIONAL

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(408) 438-8400 TELEX: 172373

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Copies	Product	Price	Totals
__	Turbo Pascal 3.0 w/8087 & BCD	$99.95	$____
__	Reflex: The Analyst	149.95*	$____
__	Reflex Workshop	69.95*	$____
__	Reflex, Reflex Workshop	199.95*	$____
__	Turbo Prolog	99.95	$____
__	Turbo Pascal for CP/M-80	69.95	$____
__	Turbo Database Toolbox	69.95	$____
__	Turbo Graphix Toolbox	69.95	$____
__	Turbo Tutor 2.0	39.95	$____
__	Turbo Editor Toolbox	69.95	$____
__	Turbo GameWorks	69.95	$____
__	Turbo Lightning	99.95	$____
__	Lightning Word Wizard	69.95	$____
__	Turbo Lightning, Lightning Word Wizard	149.95	$____
__	SideKick	84.95	$____
__	Traveling SideKick	69.95*	$____
__	SideKick, Traveling SideKick	125.00*	$____
__	SuperKey	69.95	$____
	Outside USA add $10 per copy CA and MA res. add sales tax		$____
	Amount enclosed		$____

Prices include shipping to all US cities.

Carefully describe your computer system:

Mine is: __ 8-bit __ 16-bit

I use: __ PC-DOS __ CP/M-80 __ MS-DOS __ CP/M-86

My computer's name and model is: ____________

The disk size I use is: ☐ 3½" ☐ 5¼" ☐ 8"

Payment: VISA MC Money order Check

Credit card expiration date ___/___

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CODs and purchase orders WILL NOT be accepted by Borland. Outside USA make payment by bank draft, payable in US dollars drawn on a US bank.

*Limited Time Offer

**YES, if within 60 days of purchase you find that this product does not perform in accordance with our claims, call our customer service department and we will gladly arrange a refund.

All prices are suggested list prices and are subject to change without notice.

GF6

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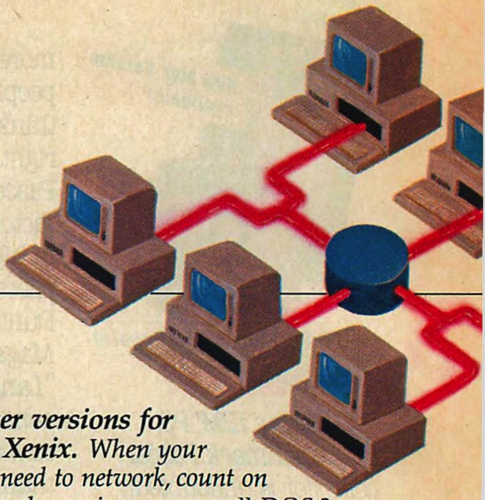

When you're serious about application development, there's just one choice for file management: Btrieve. With what *Computer Language* calls "near mainframe functionality[1]", Btrieve sets the file management standard for PC applications. With Btrieve loaded in your PC, your programs can use simple subroutine calls to retrieve, store and update records.

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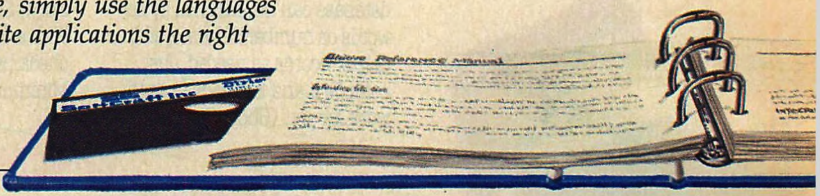

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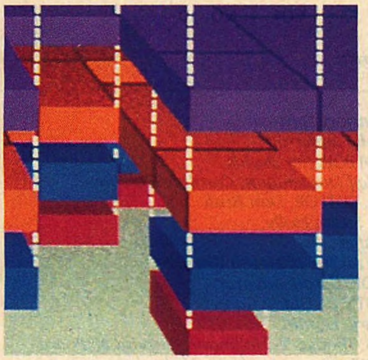
OCTOBER 1986

PC TECH JOURNAL

VOLUME 4, NUMBER 10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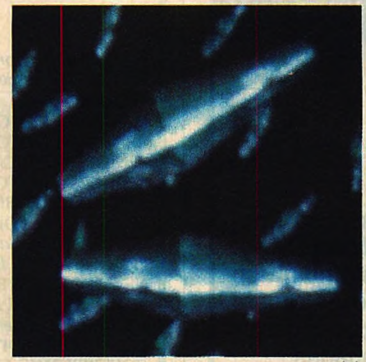
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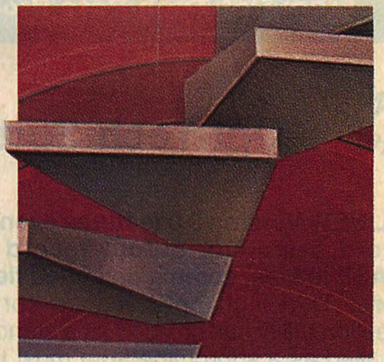
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BPA SELECTED MARKET AUDIT DIVISION

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Before you consider the new Hercules Graphics Card Plus, consider the technology behind it.

On July 1, Hercules™ introduced a product that will forever change the way information is displayed on a PC.

The product is called the Hercules Graphics Card Plus.

We gave it that name because it gives you the same hi-resolution text and 720x348 graphics that made the original Hercules Graphics Card famous.

Plus it gives you RamFont.™

RamFont is a radical new hardware mode that combines the speed of text mode with the flexibility of graphics mode.

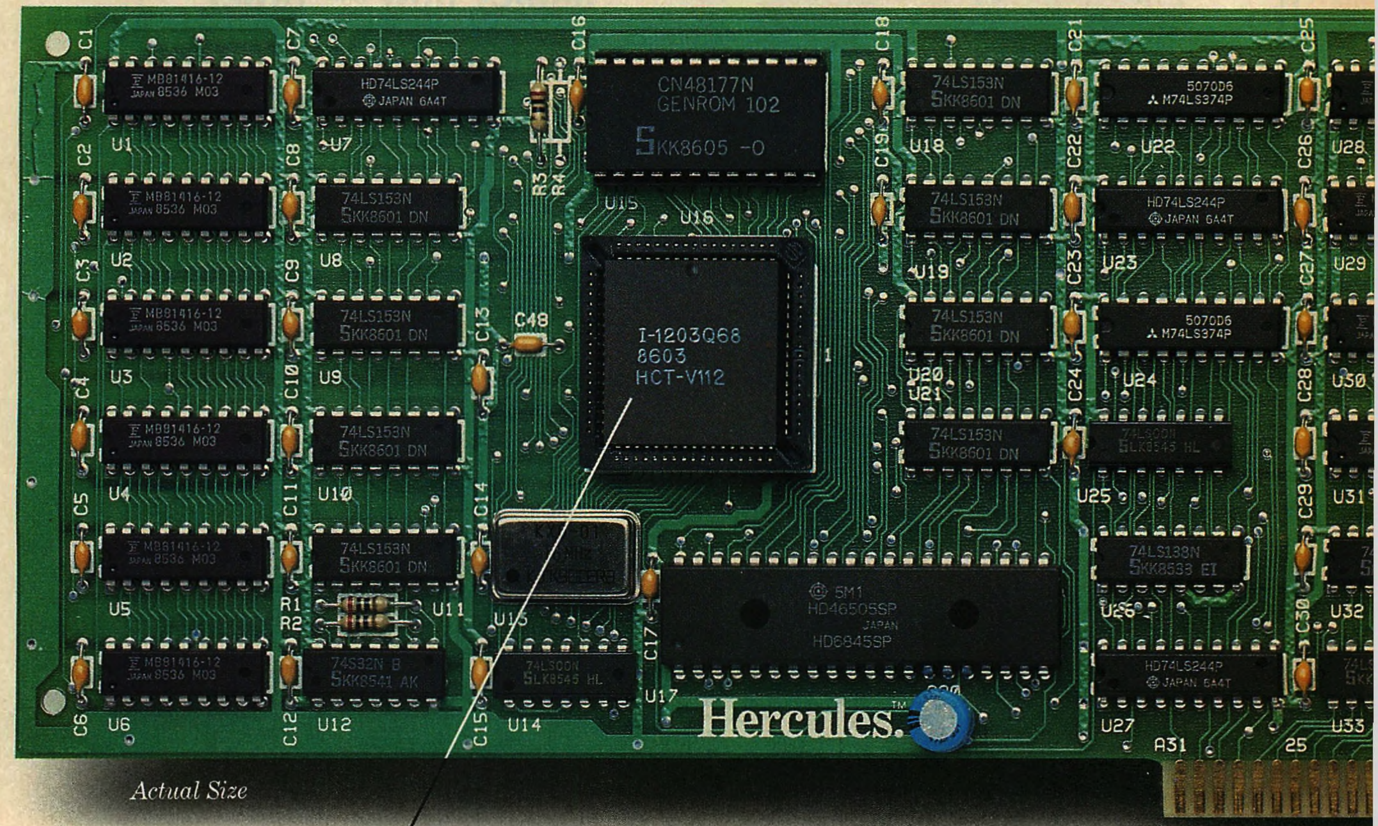
And opens up a whole new world for software.

The world according to RamFont.

In the old days (before July 1), programs like Lotus® 1-2-3®, Symphony,™ Framework™ and Microsoft® Word had to use graphics mode to display multiple fonts and variable text sizes, or to mix text with graphics.

But graphics mode is a whole lot slower than text mode. Up to eight times slower.

Enter RamFont.



Actual Size

The heart of the Graphics Card Plus: the V112 microchip, Hercules' next generation video processor that makes the RamFont mode possible.

It lets all the programs we just mentioned (and plenty more in the future) do all the things we just described, all on one screen.

At precisely the same speed as text mode.

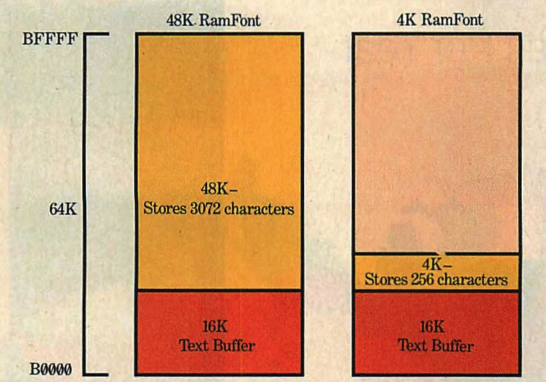
How RamFont works.

Like text mode, RamFont uses a 16-bit word to represent a character on the display.

Unlike text mode, however, the 48K RamFont mode uses a 12-bit character code instead of an 8-bit code.

Which allows you to choose from an astonishing 3072 different characters.

While setting the size of your screen cells from eight to nine pixels wide and from four to 16 scan lines tall.



The new RamFont mode displays 3072 programmable characters at the speed of text mode, or replaces the standard character set with one of your choice in 4K RamFont mode.

To help you design your own RamFont characters and symbols, we've included a font editor called FontMan.™

Along with a set of 25 sample fonts to start your library.

And since the 4K RamFont mode can accept 8-bit character codes, running your text mode software with your favorite font is as simple as loading it into RAM.

Just for the record, RamFont supports the standard character attributes of reverse, high-intensity, blink and underline.

Plus two new RamFont attributes: boldface and strike-through.

What price success?

While we're on the subject of technological breakthroughs, let's not forget the suggested retail price.

Think of it. You get everything the original card gave you.

Plus RamFont.

Plus FontMan.

Plus a free printer cable.

Plus a parallel printer port that you can now disable if there's a conflict with another port in your system.

$299.

Suggested retail price.

All for just $299—about half the price of the original Graphics Card.

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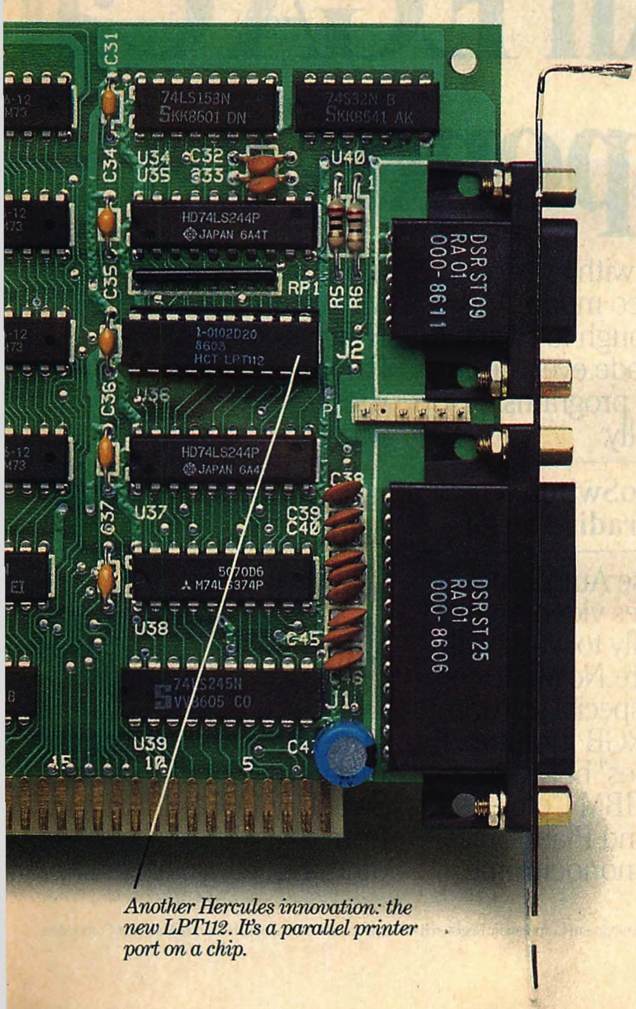

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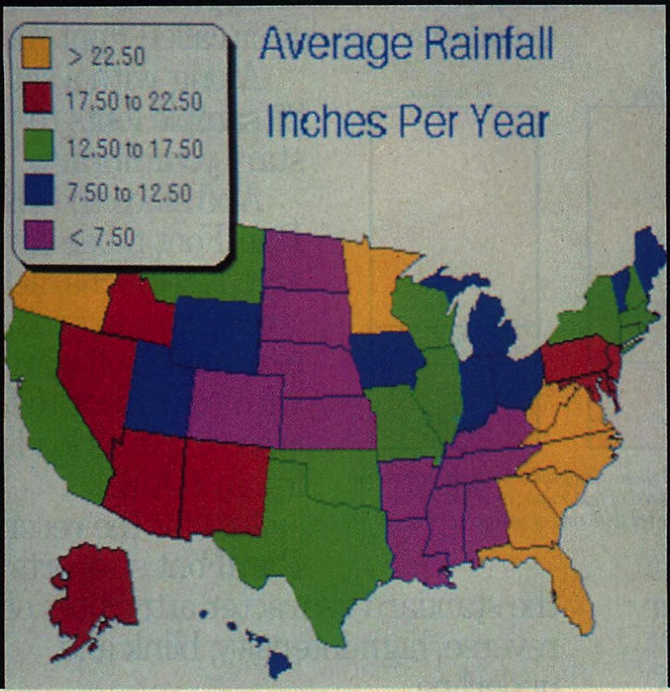
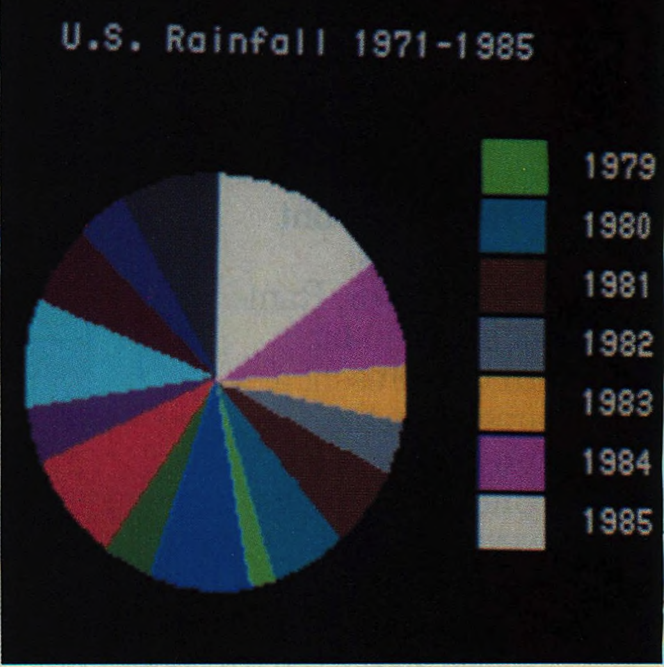


EGA Mode



Plantronics Mode

Finally, An EGA Car
Responds To Yo

Introducing The Paradise AutoSwitch™ EGA Card.

You've decided you want an EGA Video Card because it offers the best quality text with high resolution color graphics. The problem is that older versions of popular software, like Lotus 1A, (and some current versions too) won't work with the EGA standard. That's a problem because in the course of your workday you'll need to use software written for different video modes.

Paradise has the answer. The Paradise AutoSwitch EGA works with every popular PC video mode. And is smart enough to switch to the right mode every time you change programs. Automatically.

AutoSwitch. Only Paradise has it.

The Paradise AutoSwitch EGA changes video modes automatically to work with your software. No Mode commands. No special software to run. On RGB monitors it "autoswitches" between EGA, CGA (IBM Color Graphics) and Plantronics modes; on monochrome monitors between EGA, MDA (IBM Mono Text) and Hercules modes. The Paradise AutoSwitch EGA runs any PC software you want. Immediately. Automatically. That's something ordinary EGA Cards can't do.

Runs all EGA, CGA, MDA and Hercules Software with true hardware level compatibility.

True hardware compatibility makes the Paradise AutoSwitch EGA Card different from other EGA Cards. No other EGA Card offers the

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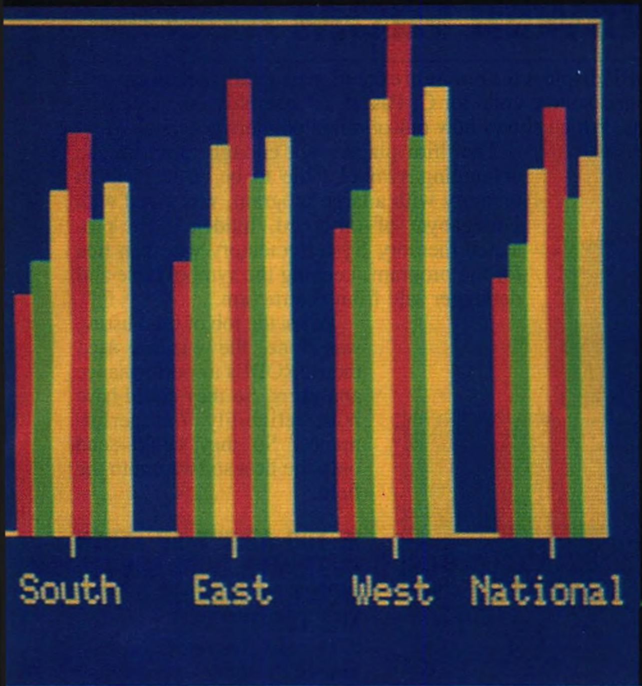

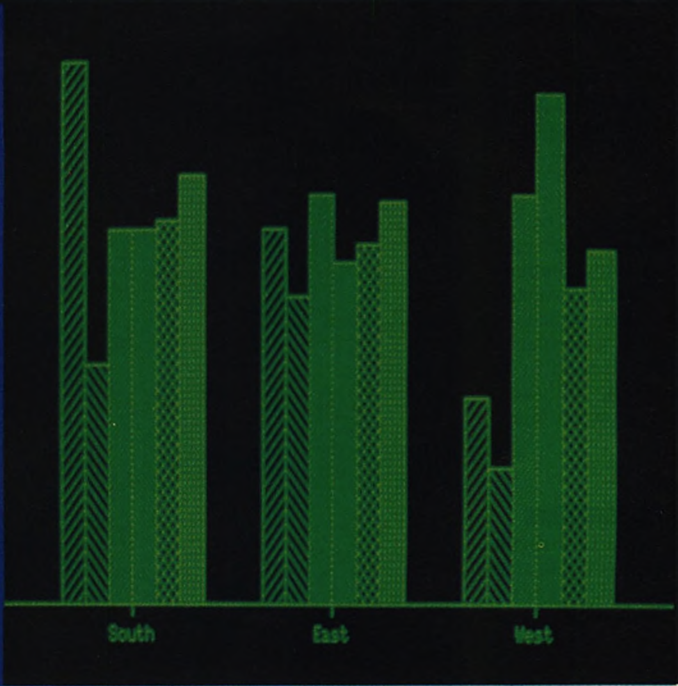

CGA Mode

Hercules Mode

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6845 CRT controller included on the IBM Monochrome, IBM Color and Hercules Cards. The Paradise-designed PEGA video controller chip has the equivalent of a 6845 inside. That means when the Paradise AutoSwitch EGA runs EGA software, it's an EGA card; when it runs IBM Color Graphics (CGA) software, it's a CGA card; when it runs Hercules software, it's a Hercules card. No "batch files," special software or complicated installation. No incompatibility hassles. EGA with true 6845 hardware compatibility.

The Simpler the Better.

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The Paradise AutoSwitch EGA Card. Just what you would expect from the innovators in Video Technology.

PARADISE
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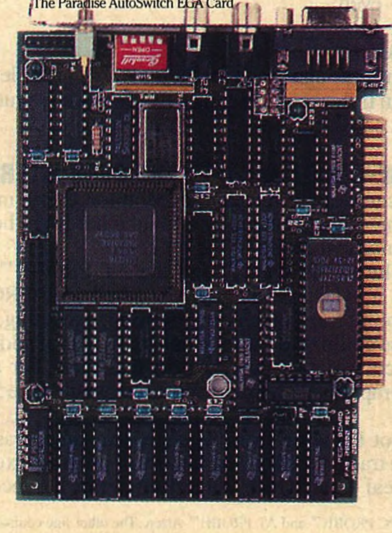
The Paradise AutoSwitch EGA Card



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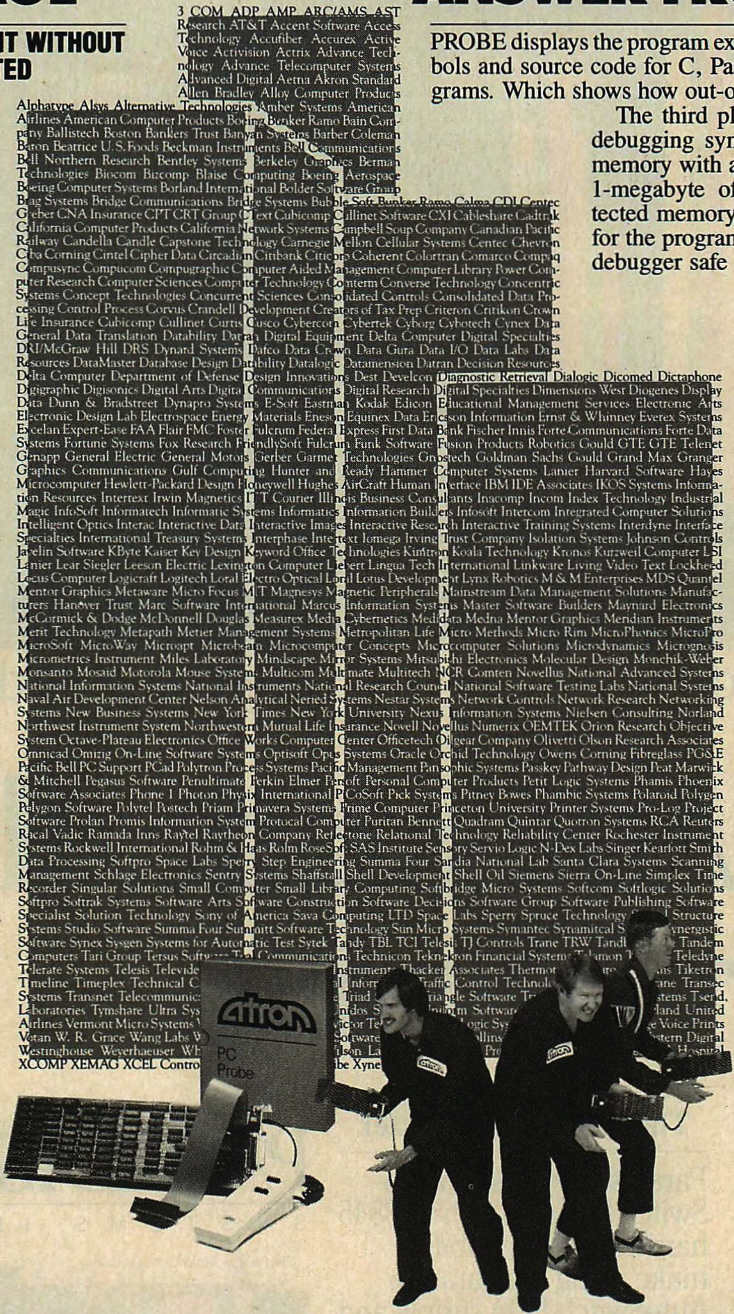

This is the city saved by the Atron bugbusters. Your city. Full of wizards, with hundreds of millions of dollars invested in wringing every ounce of intelligence and performance out of your PC. It used to be plagued with the toughest software bugs known to mankind.

PLAGUES OF BIBLICAL PROPORTIONS

The first and most difficult plague was impossible to trap with software debuggers. These were carnivorous bugs which randomly overwrote programs, data, even the debugger. Nastiest were the ones that slipped in once every few hours, or changed their behavior after each new compile. Forty days and forty nights of recompiling, *trying something else*, caused many a would-be resident of the city to run screaming into the wilderness, never to be heard from again.

Second came the plague of not knowing where the program was, or where it had recently been. This compounded the first plague: How could anyone know *what* caused the random memory overwrites? Add to this random interrupts and timing dependencies, and you begin to understand *The Fear* that gripped the city.

Then came the last plague, which brought the wizards to their knees before they even started debugging. Their towering programs consumed so much memory, there wasn't enough room for their symbol table, let alone debugging software. Even if they could get past the first two plagues, this one killed their firstborn software.

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The Atron solution came as a revelation: Monitor every memory reference and every instruction executed, by adding a hardware board to the AT or PC with an umbilical probe to the processor.

The result? Wham! The PC PROBE™ and the AT PROBE™ saved civilization as we know it. The first plague was cured with PROBE'S hardware-assisted breakpoint traps on reading, writing, executing, inputting and outputting. These could be done on single or ranges of addresses, and could include particular data values. All in real time. For a mere software debugger to attempt this, a 1-minute program would take 5 hours to execute.

The second plague, not knowing from whence you came, was cured with PROBE'S real-time trace memory. The history of program execution is saved on-board, in real time. Once a hardware trap has occurred, PROBE displays the program execution in detail, including symbols and source code for C, Pascal, or assembly language programs. Which shows how out-of-range pointers got that way.

The third plague, not enough room for the debugging symbol table to be co-resident in memory with a large program, was cured with 1-megabyte of on-board, hidden, write-protected memory. System memory was then free for the program, keeping the symbol table and debugger safe from destruction.

When the job of bugbusting was done, the wizards used their PROBEs as performance analyzers. So they could have both reliability *and* performance. So they could send only the best software into the field.

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If you use a product from one of the companies in *The City*, you owe life as you know it to Atron. Our guess is that 99% of all PCs, XTs and ATs have at least one product debugged with Atron bugbusters.

FREE 44-PAGE BUGBUSTING BIBLE COULD MAKE YOU A PROPHET, AND YOUR COMPANY A PROFIT.

We've written a complete tutorial on state-of-the-art bugbusting. And it's yours, free for the asking. Full of examples and illustrations, it will show you how the wizards work their magic.

If you're tired of suffering the wrath of program bugs, call Atron today. You could be busting bugs, and sales records, tomorrow.

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THE BUGBUSTERS

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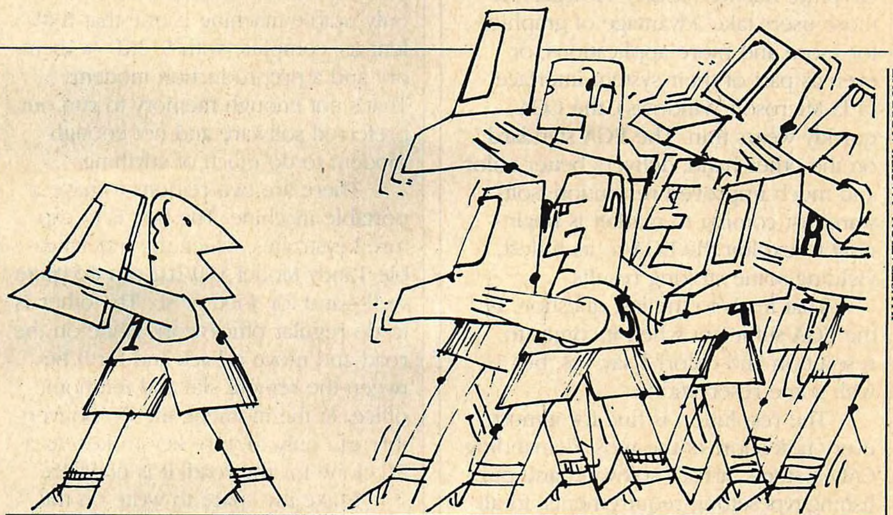

ILLUSTRATION • MACIEK ALBRECHT

In this issue we present two articles, written by John T. Cockerham, on the subject of IBM's Enhanced Graphics Adapter (EGA). The first, "The EGA Standard," which can be found on page 48, is a technical overview of the EGA. It includes extensive listings of programs designed to exercise the IBM board and its many clones for the purpose of compatibility testing. Following this on page 80 is "The EGA Spectrum," the first of a two-part article reviewing many of the EGA-compatible boards that are currently on the market. This first installment deals with adapters that functionally duplicate the IBM EGA. The review will continue in November with an examination of several boards that offer additional graphics functionality beyond the EGA's specification.

IBM announced the EGA subsystem in September 1984. It is a complex device—one that has taken after-market vendors almost an entire two years to reproduce. Today, a flood of boards has reached the market and more arrive each week as board manufacturers take advantage of a chip set designed and built by Chips and Technologies. All this activity is having its effect.

Demand for the IBM board is dropping because its price is more than double the street price for the compatibles, all of which have a full 256KB of on-board memory. A recent price from PC Connection for several name-brand boards was $369; a generic brand was $279. PCs Limited recently quoted $269 for its own EGA card. The prices are so good that a complete subsystem, consisting of a board and the highly regarded NEC MultiSync monitor, can be purchased for a little more than $900. The equivalent IBM configuration is about twice as much at $1,831, IBM's original price.

Even $900 may seem like a lot, especially considering that the original IBM display subsystems (or their compatibles) can be purchased for less than $500. Nonetheless, the $900 price tag and the EGA's high functionality drives the market inexorably toward the EGA as a standard. Retailers report more and more orders specifying EGA capabilities; several have said that they stock at least one compatible subsystem to sell in place of the IBM product.

If $900 is too much, the EGA has a trick up its sleeve. Because an EGA compatible has to be able to drive the IBM monochrome display to meet the EGA specification, the buyer has the opportunity to choose monochrome now and upgrade to color later. The IBM configuration to do so lists at $799. Specifying the Amdek 310A monitor in combination with a name-brand board could yield a street price of $518. The EGA compatibles thus offer a clever way to upgrade the millions of text-only systems with the IBM Monochrome Display and Printer Adapter. In fact, a few of the EGA clones even include a printer port, perhaps in anticipation of an adapter replacement market opportunity. No color, but cheap.

BUT IS IT WORTH IT?

Cost is one thing; utility is another. Is the EGA standard really worthwhile, or is something waiting around the corner that will make the EGA look tame?

Several new products are rumored to be very close to announcement, perhaps in time for Fall COMDEX in November. A big rumor, unconfirmed by *PC Tech Journal*, has IBM announcing an enhanced EGA—one with more colors, the bugs fixed, and other improvements. Another IBM rumor predicts a new analog subsystem with millions of colors. The computer press has paid a great deal of attention to the inevitable introduction of graphics subsystems with coprocessors, particularly those using the Intel 82786 chip. The rumors reflect a desire for new features beyond those delivered by the EGA.

But that's not really the important question. Better to ask, "Is the current EGA standard a viable one for a base graphics standard for IBM and IBM-compatible desktops?" In other words, would I accept a desktop computer if it came with the EGA built right in to the system motherboard?

The answer is yes, although I will reflect in a moment on some problems to keep in mind. The average desktop computer needs two features: high-quality text and some graphics capability. The IBM monochrome adapter is popular because the text is so beautiful and the display subsystem is relatively inexpensive. The EGA standard sacrifices

one horizontal dot per character in text resolution in comparison to the monochrome adapter, but the more important vertical resolution is the same, still yielding crisp, readable characters. Some other text sacrifices are made (underlining is difficult), but the availability of color offsets the loss.

Graphics capability is more difficult to analyze. Ninety percent of all users could probably get along just fine with the original IBM standard, the Color Graphics Adapter (CGA). However, as those users take advantage of graphics for more and more applications, or even as part of their system interface (a la Microsoft Windows), the CGA quickly wears thin. The EGA standard, on the other hand, delivers better color and much improved resolution; software just coming to market is beginning to exploit the EGA to its fullest, yielding some striking results.

That leads to the last question. Is the EGA sufficient when it comes to resolution and color? I say yes, but with some reservations.

The resolution is fine for almost every task short of the most demanding CAD systems, artist's software, and publishing/typesetting requirements. In all these areas, the EGA is usable, but serious practitioners will want more. For the mass market, however, the resolution is fine. It is just about all that most of us are able to afford because the price of display monitors rises rapidly as the resolution increases. Displays for EGAs retail for less than $600, which is a reasonable price.

My biggest reservation is the limited color selection. The IBM standard calls for, at best, any 16 colors from a fixed palette of 64. Sixteen colors provides sufficient flexibility for much desktop work and for most of the presentation graphics that businesses might produce. The EGA would be more satisfactory for creating images, however, if the full set of 64 colors (or even more) were available at all times.

That is a minor drawback. For business graphics, presentation graphics, much CAD and CADD work, some drawing, and even some desktop publishing, the EGA is more than satisfactory. As long as desktop architectures remain open so that new display technologies can be plugged in when they become available and are needed by the user, the EGA is a good base-level display subsystem.

I hope (and expect) to see the EGA standard built into a motherboard before long. It is bound to happen.

CONVERTIBLE WOES

PC Tech Journal has long needed a couple of portable computers around the office, so we finally took the plunge with IBM's new entry, the PC Convertible. The machines are satisfactory, and I think we will get our money's worth—that is, when we can finally start using them.

Our two purchased Convertibles are languishing in our office sans expansion memory and modem. The only usable machine is one that IBM lent us, complete with 512KB of memory and a preproduction modem. That's not enough memory to run our preferred software and not enough modem to do much of anything.

There are two reasons to have a portable machine. The first is to capture keystrokes, which the indefatigable Tandy Model 100/102 can do quite well—and for $400 or so. The other is to do regular office work while on the road and move it back and forth between the remote site and the home office. At the moment, the PC Convertible can only capture keystrokes. As a PC clone for the road, it is nowhere.

I take the space to write on this subject because it represents another major letdown from IBM—of the same "announce-it-today-and-offer-it-much-later" syndrome. The first really bad case of this came with the 360KB disk drive for the PC/AT, which is, incredibly, almost impossible to obtain, even today, two years after the AT was announced. The second case is the Convertible's modem, which we have all read about. Rumors abound; whatever the truth, IBM makes a serious mistake in failing to deliver a critical component, especially one so much needed for a *portable* computer. But the third failure is unfathomable, and it should turn IBM's face crimson with embarassment. It's one thing to design the machine for 512KB in the first place, when everyone installs 640KB. But it's quite another not to be able to deliver the memory expansion boards.

IBM told *PC Tech Journal* that modems had turned into a problem and would be delayed. However, it denied that any delivery problems exist with memory. That does not explain why retailers cannot quote delivery on memory expansion.

These problems cast a long and unfavorable shadow upon IBM's reasonable entry in the portable sweepstakes. If I had known about the delay for vital components ahead of time, I would have written the order to be filled completely or not at all, or perhaps I would just have held the order until I knew all parts would be available, or looked more seriously at the Toshiba T1100 PLUS (see Tech Releases, this issue, p. 35). As it stands now, I have spent the money for a couple of useless machines.

I feel cheated.

—WF

P.S.—STB has announced a 384KB expansion board, the C-Ram 384, for the Convertible with availability in mid-September (see Tech Releases, this issue, p. 32).

PCTECHLINE UPDATE

The telephone number for PCTECHline, now operating from our new Columbia, Maryland, office, has been changed to 301/740-8383. The PCTECHline number is always published in our masthead.

Improvements to our system are planned. Six telephone lines have already been installed in our new lab for this purpose; the lines will be put into service one by one as demand warrants. The bottleneck in our planning is our fondness for PCTECHline's software; unfortunately, its current multiline capabilities are not to our liking. We hope that better solutions are forthcoming from the vendor, Micro-Systems Software.

Part of the plan is to increase the capacity and performance of the PCTECHline computer. We do not yet know how this will be accomplished. One idea is to install an RT/PC that has the performance to handle at least six lines and the necessary software (AIX) to control them. We would value the experience gained on the RT and users would benefit from the expansion of services it would allow.

We apologize for any disruption of service that may be caused by our move to Columbia or our experiments with new equipment and service. As always, we invite your comments and suggestions for PCTECHline.

—WF

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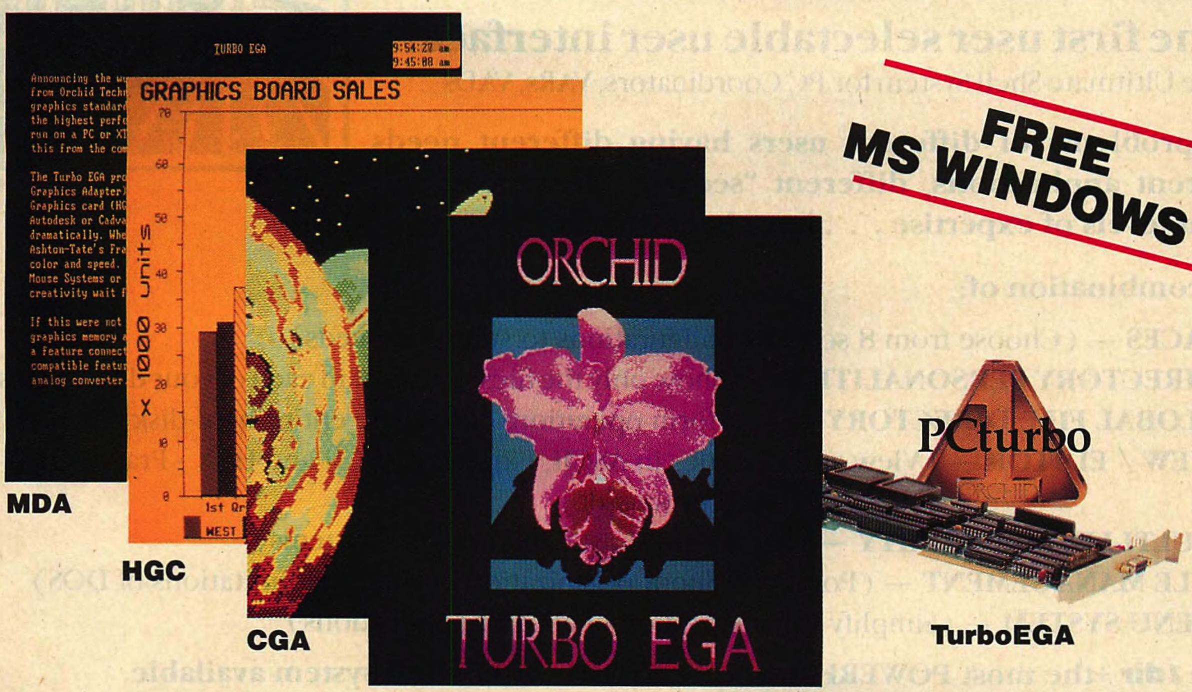

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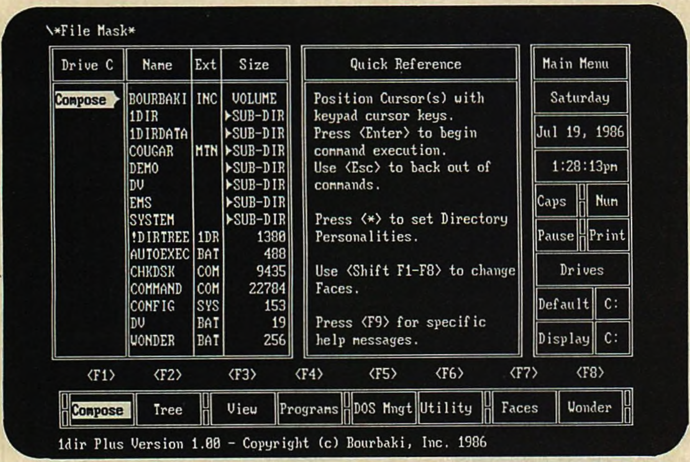

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Number of Screen Display Options	8	3	2
Copy, Erase, Rename, Mkdir, Move . . .	Yes	Yes	Yes
Multiple File Operations — flagging	Yes	Yes	Yes
Directory Map — Tree	Yes	No	Yes
Multi-Mode VIEW / EDITOR	Yes	No	No
Global File Directory (Entire HD)	Yes	No	No
Global File Operations	Yes	No	No
Directory Personality Capability	Yes	No	No
System Statistics Display	Yes	Yes	Yes
Change File Attributes	Yes	No	Yes
Context HELP	Yes	No	No
Multi-level Security	Yes	No	No
Locate Command	Yes	No	No
Multi-User / Network Oriented	Yes	No	No
Individual User Applications Menus	Yes	No	No
Works w/Unlimited # of Directories	Yes	?	No
Print Files	Yes	No	Yes
Print Directories and Tree Structure	Yes	No	No

If you are a PC Coordinator, consultant, systems integrator, VAR, VAD . . . ***1dir*** + was designed for you. Set up simple to use systems for users, without compromising your ability to access the power you need to make changes, to add software, to clean up the hard disk . . .

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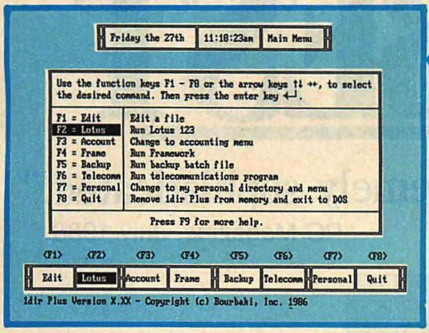

The MANY FACES of ***1dir*** +

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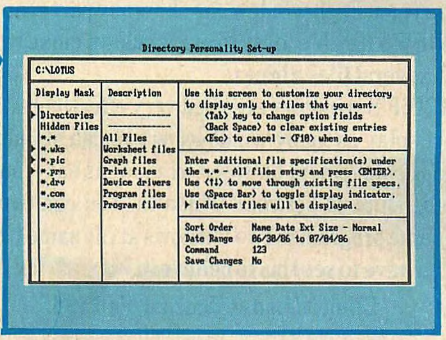
FROM THE SIMPLE TO THE SOPHISTICATED

to any of the others anytime you want.

We've provided these options because we recognize that different users have different applications needs and levels of expertise. The illustrations presented here are only four of the eight available.



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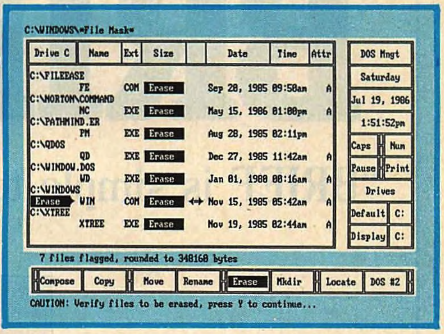
1dir +'s Directory Personality feature enables you to customize each and every directory display. Show only your WKS, PIC and PRN files in your LOTUS directory; your CMD, FIL and NDX files in dBASE; your LTR,



RPT . . . files in word processing, etc.

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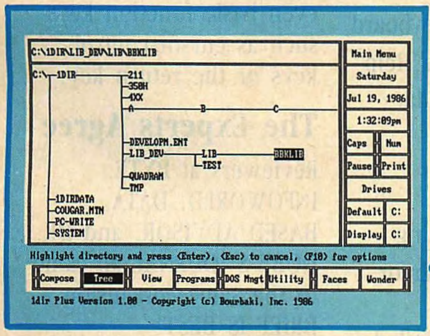

DIRECTORY MAP - TREE DISPLAY

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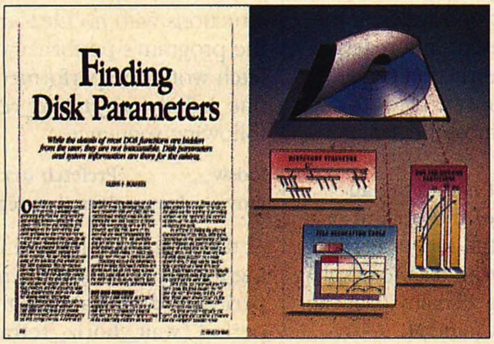

FINDING HELP

In his excellent May 1986 article "Finding Disk Parameters" (p. 112), Glenn Roberts seems not to have discovered the significance of what he calls the Alt_AD field in the table pointed to by function 32H. This field is actually the unit number that is to be passed to the driver when accessing the drive in question. It matches AD for units implemented by IBMBIO.COM's block driver, but starts over at zero for each loaded driver. Since RAM disk drivers seldom define more than a single unit, he is correct that Alt_AD is generally zero for a RAM disk. However, a two-drive Bernoulli Box driver has a zero in its first unit's Alt_AD field and a one in the second. Also his NH-1 field actually contains the shift count required to convert between sectors and clusters, so that

1 << "NH − 1" = = "SPC − 1" + 1

Perry C. Hutchison
Tigard, OR

A fine article by Glenn Roberts on disk formats. One note about the undocumented interrupt 32H: it is exactly the same as the (incompletely) documented interrupt 1CH, except for the annoying, but convenient values placed in the registers AL, CX, and DX, and the constant 16H difference between the values in BX. That is, if after an interrupt 1CH you decrement BX by 16H, then DS:BX will point to the same table that they would have after interrupt 32H.

David Ehrlich
New York, NY

I read Glenn Roberts's "Finding Disk Parameters" with great interest. I would, however, like to report some corrections to the interpretation of some of the table entries returned by function 32H in figure 3. The second byte is the unit number in the device driver referenced by the device header pointer. The first byte is the logical drive number in the system. For the units of the first device driver, the first two entries of the table will be the same. The next device driver will start numbering units at zero, in effect, a RAM disk.

The byte at offset 5 is the log base 2 of the number of sectors per cluster. The word at offset 22 should be two separate bytes. The byte at offset 22 is the media descriptor byte. The byte at offset 23 indicates whether the drive has been accessed since system power up. It has the value −1 until the first access has occurred.

It also should be noted that three other undocumented DOS functions deal with this disk parameter block (DPB). Function 1FH is the same as 32H but applies to the default drive only. Function 52H returns ES:BX pointing to the root of the chain of DPBs. Function 53H constructs a DPB at ES:BP from a BIOS parameter block (BPB) that is pointed to by DS:SI.

Stan Mitchell
San Jose, CA

The byte at offset 5 in the DPB does indeed represent the shift count (or, equivalently, log base 2) of the number of sectors per cluster, rather than the number of heads minus one as reported in the article. The head count reported by the INFO program is correct, however, since it is taken from the boot parameter block on the disk.

With regard to Mr. Ehrlich's suggestion that functions 1CH and 32H return essentially the same pointers (except for a constant 16H difference), this is true for DOS 2.x but not DOS 3.x.

As for the interpretation of the DPB byte at offset 23, I have not tried to verify that this byte is set to FFH until the drive is accessed. For users of function 32H, this is perhaps a moot point because the function forces a media check, which in turn clears the byte; thus in all of my observations, the byte has been zero. If you were to search the chain of linked DPBs (using function 52H to find the starting point as Mr. Mitchell suggests), you could look at this byte without forcing a media check.

My thanks to these gentlemen for their valuable help in further clarifying function 32H and the other undocumented DOS function calls.

Some readers have called me asking how to patch the SHOW and INFO programs for use under DOS 3.2. The version check in these programs can be patched to accept DOS 3.2 by renaming the .EXE file to have an extension .DAT, and then using DEBUG to change the byte at offset 5E7H from 36H to 40H. The patched file then can be renamed back to a .EXE file and executed as before. This patch has the same effect as changing the value of MAX_VERSION in the source code from 310 to 320. The patch location is the same for both INFO.EXE and SHOW.EXE.

—Glenn Roberts

SCREEN PLAY

I would like to address several points with regard to Augie Hansen's "Instant Screens" (June 1986, p. 96). The article presented a fairly good discussion of the basic operation of the IBM Color Graphics Adapter (CGA) and the need to check for synchronization signals before writing to display memory. My main points of contention, however, are with his code implementation.

The first point concerns the statement "One byte of data can be copied safely to or from display memory during...[horizontal retrace]." In listing 1, the **copy_block** routine wastes several critical clock cycles with the **cli** and **movsb** instructions. Before the first loop is entered, interrupts should be turned off with **cli**. Even the realtime clock interrupts can cause snow on the screen if this is not done. Also, in a worst-case analysis, the four clock cycles required to fetch the **cli** instruction opcode can add to the snow problem.

Using **movsb** also lengthens the write sequence by several clock cycles. If the data were already present in a register, an **xchg** and **stosw** instruction sequence could be used to write two bytes to display memory in almost the same amount of time.

The second point is that the author's **copy_block** uses the vertical retrace period and not the longer vertical blanking interval to write data to display memory. Almost twice as many data can be written during this interval.

The routine I have suggested copies a buffer of characters and attributes to display memory almost twice as fast as Mr. Hansen's. Since screen updates are performed in approximately one-twentieth of a second, they appear instantaneously to users, without the need to switch active visual pages.

J. Steven Cathcart
Digital Communications Associates, Inc.
Alpharetta, GA

I found Augie Hansen's article on "Instant Screens" to be well written, full of good information, and timely. However, I have a few enhancements to offer.

The author states that no more than a single byte can be transferred during each horizontal retrace without risking snow. His method should take about .099 second to transfer a full screen. A slight modification allows the routine to transfer two bytes per retrace (and in less time) thereby allowing full screen updates in .078 second. The technique employed here also may be useful in other situations. The following explains the changes required.

In his **wait_horiz_retrace** routine, Mr. Hansen uses a **movsb**, an instruction that not only moves a byte from the application buffer to the screen buffer, but also increments the pointer registers (**si, di**). Of course, all this service comes at a price: **movsb** takes 3.77 microseconds to move one byte. It would be preferable to have something faster. The trick is to replace the **movsb** with the following two instructions:

```
mov     ax,bx  ;Retrieve prefetched word
stosw          ;Store it in the screen buffer
```

This sequence moves two bytes to the screen buffer in 3.56 microseconds. I am assuming that the **bx** register is already loaded with the appropriate two bytes. Fortunately, that is easy to accomplish by prefetching two bytes from the application buffer while waiting for horizontal refresh. This is the heart of the technique. In some sections of a program, time is critical; in other sections, a user could insert 50 additional instructions with no measurable effect on the program's performance. The prefetch would be performed in the routine called **wait_horiz_refresh** by the following sequence:

```
lodsw          ;Prefetch next word
mov     bx,ax  ;Save it in reg. bx
```

At this point, the routine is simply waiting for the start of the screen painting period. It then waits for the end of that period (**wait_horiz_retrace**). Basically, the program is just sitting for about 50 microseconds—the prefetch uses 4 of those. Note that the use of **lodsw/stosw** provides the same automatic incrementing of pointers as before, except that they now have two byte increments.

In addition, it appears that screen updates that use multiple blocks (more than 428 words) can be performed more quickly by trading off the last one or two horizontal retrace periods to ensure that we catch the start of the next vertical retrace period. It looks like we are losing one-sixtieth of a second on each block, waiting for vertical refresh. This could cost about 85 milliseconds on a full-screen update. Has anyone done serious time tests on this?

Gordon Arbeitman
East Greenbush, NY

I enjoyed Augie Hansen's technical discussion of programming around the problems of the IBM CGA. His article ended a bit too soon, however. I wanted to see some specifics about how a program can identify a non-IBM host.

For example, the machine model byte at F000:FFFEH yields reliable information for the IBM family of PCs, but is that same location used by other vendors? Compaqs frequently have 2DH or 9AH residing at the address, but I have seen nothing to confirm that this is a machine identification.

Please note that the techniques Mr. Hansen discusses in this article are readily available for Turbo Pascal programmers through the Boosters utility package, a free product available on many bulletin board services or directly by calling 404/923-6879.

George F. Smith
Lilburn, GA

As stated in the article, my approach to handling direct screen access is just one of many possible methods. The primary advantages to my method are that it is fast enough for most applications and that it works reliably and unchanged on every IBM PC and compatible (ex-

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cept those with differing display memory locations) regardless of processor speed.

Although having the data present in a register (before entering the **copy_block** *routine) and reducing the number of instructions in the loop ultimately may allow two bytes to be transferred in one horizontal retrace period, care should be taken. In my design, I deliberately used fewer horizontal retrace periods than are available (188 versus 240) to preclude missing the start of the next vertical retrace period and to allow for the effects of interrupts. I detected no wasted frames using the method described.*

Mr. Cathcart's method works very well on most machines if the code is reassembled and relinked for each machine and clock speed combination independently. He uses an interesting method to determine the start of the vertical blanking interval. It is a method that I examined for possible use, but rejected out of concern that it was not universally applicable.

No port on the display adapter, nor any system storage location, marks the vertical blanking interval directly, so starting time must be estimated. If the display adapter locks the DISPEN (display enable) signal while in the vertical blanking period, as the IBM CGA does, a time delay can be used to wait after a horizontal retrace for another one. If none occurs at the expected time, then it is safe to assume that vertical blanking is in progress. The time delay must be generated by a timing loop that is, regrettably, dependent upon the system clock rate and the processor type.

I have been told (although I have not as yet confirmed) that some color/graphics boards let the DISPEN signal continue to run during the vertical blanking interval, which would effectively negate the detection technique just described. I was unable to conceive of another way to detect the start of vertical blanking, so I elected for the conservative route of using the shorter but reliable retrace indication.

I keyed in the changes suggested by Mr. Arbeitman and got the same disturbing result on an AT&T PC 6300, an IBM PC, and a PC/AT. Each machine locked up and had to be rebooted after displaying unrequested screens full of arbitrary patterns. Because only four lines of code changes are noted, it was easy to check that I had made them as suggested. Other changes are needed, however, to implement the proposed method. The **ax** *register is used by the* **lodsw** *instruction, causing the block*

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FLEXIBLE

As many possibilities as Vermont in June.

WINDOWS FOR DATA HAS UNPRECEDENTED FLEXIBILITY.

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*Steven Weiss, Stratford Systems (18 yrs; 1 yr)**

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count already in ah to be overwritten, which causes the ST program to take a random walk through memory.

Mr. Arbeitman's method is theoretical and was not tested. (In addition to protecting the contents of ah, I suspect that other changes are needed to implemented the method fully.)

In response to Mr. Smith's question, I have found no reliable way to determine the exact hardware configuration. No agreement exists as yet among various PC manufacturers about using the machine ID byte for this purpose. Legal difficulties likely would result with non-IBM vendors attempting to coordinate the use of that byte. Having programs ask the user what his machine type and processor speed are will not be particularly fruitful either. Some less technical PC users simply are not aware of details such as these.

—Augie Hansen

ACQUIRING FEEDBACK

We at Western Telecomputing were pleased with the review of our ICIS data acquisition system in the May 1986 issue ("Digitizing Analog Data," Eric M. Miller, p. 52). We have made some changes as a result of assessing the reviewer's comments, such as adding solder mask to our boards and an index to our instruction manual, and also would like to point out some additional features of the ICIS system.

The software package used to operate the ICIS system is not copy protected, and we now include a copy of the source code on disk at no additional charge if it is requested at the time of order. We also are in the process of writing a driver to make our system compatible with the Labtech Notebook software package, and we now have a driver written in C that allows programs written in that language to access the ICIS cards.

The ICIS system can have as many as 64 differential analog-to-digital (A/D)/frequency input channels and 48 digital I/O channels with the addition of a second expansion card. The ICIS boards can be installed in a separate enclosure, called the Standalone, that communicates to the PC over RS-232 or modem link. As many as 64 of these systems can be monitored on a single PC.

The ICIS also has an on-board processor that enables the system to function independently of the PC. The processor can convert data into engineering units, linearize thermocouples, and computer maxima, minima, averages, and standard deviations. Our A/D converter provides a sign bit in addition to the 12 data bits thus effectively providing a 13-bit A/D conversion. Our optional barrier terminal strip connection panel with fuse protection protects the ICIS system and the PC it is in from lightning or high-voltage transients.

Richard D. Weaver, president
Western Telecomputing Corporation
Bozeman, MT

Eric Miller's article on data acquisition boards was informative and interesting. However, some of the criticisms made deserve further comment. I question, in particular, the following three points expressed in the article.

First, the caption for the photographs on page 65 expresses surprise at the choice of ceramic capacitors on the Strawberry Tree board. I am surprised that ceramics would be automatically rejected as a choice based on temperature stability. The temperature coefficient may be anything from NPO (essentially temperature stable) to truly abominable. The point here is that capacitor type is no guarantee of performance per se. The designer faced with a capacitor selection must evaluate by specification. If this is not done, the

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product will be either unduly expensive or will not perform to expectations. My only criticism of disc ceramics is their fragility when mounted on printed circuit boards (PCBs).

Another statement in the caption is more surprising. Referring to the Western Telecomputing boards, the author states that the boards do not have a solder mask, "an unusual and substandard printed circuit board fabrication omission." I strongly disagree with this statement. Solder mask has only one purpose: to aid the manufacturer of the PC assembly in using automated soldering. The addition of solder mask will do nothing to improve the performance once soldered. To me, the lack of solder mask suggests that the units are being hand-soldered, which is a viable economic alternative for small companies doing in-house assembly. To suggest that a unit is inferior for lack of solder mask is unfair.

Finally, the article dwells heavily on frequency response considerations. While I have no criticism with what has been said on this point (it is important, after all), users should not lean too heavily on frequency response as the determining factor in their choice of an A/D module. As with any system, desired end results should be the guiding light. Consider two points in the probable applications. Most of these A/Ds seem to be aimed at low-level signals, that is, thermocouples and other such process control transducers. Such signal sources are slow to change, far slower than any of the A/D modules reviewed. Frequency response is only important to the extent that it affects the final accuracy. In application, it is not the most important consideration.

In all fairness, it is unlikely that without special effort, a typical PC will be able to acquire data at rates exceeding the capacity of most of these units. (This is especially true when using a high-level language. The author feels that high-level language support is a must and I concur, but it will not take a user long to realize that the speed trade-off is rather high, especially if he tries to do anything with the data during acquisition.) Upon reviewing the conversion speed specifications from the article, A/Ds falls into one of two categories: faster than a PC or slower than a PC. In the final analysis, the user must ensure that the A/D selected will meet the application requirements.

Robert D. Sexton
Fresno, CA

The caption that reads, "Their temperature stability is not really suitable for this type of application," (on page 65) in reference to the disc ceramic capacitors on the Strawberry Tree data acquisition board is inaccurate, as Mr. Sexton points out. The sentence should have read dielectric absorption instead of temperature stability.

We would like to take this opportunity to correct some other errors that appeared in the article as well. Table 2 describes the sample-and-hold type for the Burr-Brown 20002 module as a National LF389A; it is actually an LF398A. The slew rate equation on page 56 inaccurately describes the slew rate as being equal to the product of 2ΠF and the peak-to-peak voltage. This should say the peak voltage. The example instrumentation amplifier (IA) thus would have a slew rate of 7.957 KHz, the Burr-Brown 20002 Analog Input Module would have a slew rate of 6.4 KHz for a full-range input voltage, and the Burr-Brown 20017 Sample-and-Hold Module a slew rate of 3.2 KHz also for a full-range input voltage.

Thank you for your comments. PC Tech Journal *regrets the errors.*

—CH

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News about the Microsoft Language Family

Compiling With The *cl* Interface in Microsoft® C Compiler

The *cl* interface is an alternative driver to *msc* that comes with the Microsoft C Compiler. It is very similar to the XENIX® and UNIX™ *cc* driver. *cl* will not only compile your program, but will also compile and link multiple source files, object files and libraries, all in one step. *cl* looks at the file name extension (.c or .obj) and determines whether it is necessary to compile and link or just to link.

Example:

cl-Ox-FPa-F 2000-Zi main.c subl.obj-link mylib.lib

This example compiles main.c, creating main.obj, then links main.obj file with subl.obj, the alternative math library (/FPa) and mylib.lib. /Ox sets maximum optimization, with stack checking off. The executable stack size is set to 8K (decimal) with /F 2000(hex). Full symbolic information for use with Microsoft CodeView™ is enabled.

As with *msc*, *cl* will automatically use the PATH, INCLUDE, TMP and LIB environment variables. This allows you to set up specific search paths for your executable compiler files, include files, temporary files and library files.

All of the options available with *msc* are also available with *cl*. The default options for the Microsoft C Compiler Version 4.0 interfaces are as follows:

–As	Small Model.
–FPi	Generous floating point calls; selects emulator math library.
–Ot	Controls optimizations; favors execution time.
–Ze	Enables language extensions, such a *cdecl, far, fortran, huge, near, pascal.*

The default for the –Ox option has been changed to favor execution time.

In addition, *cl* will automatically invoke the linker and use the default C libraries. The following are some of the options that are available from *cl*:

–link "libraryfield"	The linker is invoked; linker options and alternate library names may be given.
–c	Suppress linking.
–Fe	Names the executable file.
–Fm	Creates a map file.

Third-Party Libraries Available For Microsoft FORTRAN Compiler

Microsoft FORTRAN for MS-DOS® provides a number of utilities and math libraries in the product itself, but there are a number of additional subroutine libraries that can be obtained through third-party software vendors that could speed your development even more. There are a whole range of graphic libraries such as plotting libraries (ATC, Microcompatibles, GSS), 3-D graphics (Microcompatibles), ANSI/ISO graphics (GSS, ATC), image processing (Werner Frei) and general graphics (Media Cybernetics). If you need data management, Softcraft provides Btrieve for ISAM support and Microrim provides a Microsoft FORTRAN program interface to their RBase product. Although Microsoft FORTRAN math support is already extensive, there are other more specialized math libraries available such as modelling (Mitchell & Gauthier), FFT (MicroWay, Wiley), vector, matrix numerical analysis, signal and image processing libraries (Wiley, Quantitative Technology Corporation, Systolic Systems), statistic (Wiley, IMSL, MAGUS, IMSL), and broad engineering/scientific math libraries (Wiley, NAG). General purpose libraries are available through MEF that provide communications, file management, graphics, DOS, screen handling and string handling support all in one package. Even very specialized libraries such as IEEE 488 Support (Tecmar) are available.

Contact these third party vendors for more information on their libraries for Microsoft FORTRAN or receive a copy of the Language Support Directory by contacting Microsoft.

For more information on the products and features discussed in the Newsletter,
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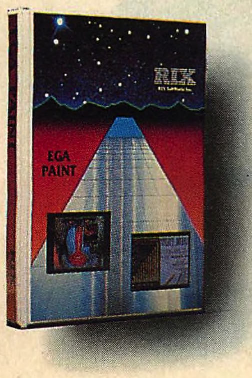


Elegant Iconoclasm

EGA Paint defies conventional wisdom by offering neither icons nor obtrusive menus in its paint program.

Ten minutes with a traditional paint program reveals its major flaw: a 13-inch screen is too small for professional illustration as it is without sacrificing 30 percent of the screen area to a menu at the outset. The menu is necessary only when changing drawing tools; while *drawing* it is an obtrusive nuisance that prevents the illustrator from getting a clear picture of the work in progress.

Keeping the menu small requires some form of shorthand. Early in 1983, Apple's MacPaint injected the concept of a paint program into the microcomputing mainstream. Before MacPaint, few knew what an icon was; afterwards, icons around the screen's periphery became (in the conventional wisdom) essential to the notion of a paint program. Icons are usually (but not always) terser than an equivalent text description of a drawing tool. Unlike text, icons can be ambiguous in the sense that two people may interpret the same icon differently. Icons must therefore be learned, just as a new language would be.

Neither icons nor obtrusive menus are necessary, however. A reasonable assembly language driver is able to move an entire EGA mode 16 graphics screen from memory to video buffer in a fraction of a second, even on a PC or PC/XT. Replacing the entire work screen with a full-screen "flash-in" menu (as Computer Graphics Group's PC Illustrator and some freeware paint programs do) is distracting and unnecessary because drawing tools fall into natural categories that need not all appear in a single menu. A system of windowed text menus that leads logically from one function to another, appearing when required and vanishing instantly at command, is an unconventional (and dare we say iconoclastic?) approach to paint programs. It is an approach that works so well, however, that *PC Tech Journal* has chosen to name RIX SoftWorks, Inc.'s EGA Paint as Product of the Month for October 1986.

The guiding philosophy here is to avoid illustrator distraction whenever possible. EGA Paint's low-profile command structure is a tree of 17 terse text menus. A mouse-directed pointer (text character 16) slides up and down to the left of the menu items; the ubiquitous scroll bar does not appear. The left mouse button descends one menu level and the center mouse button ascends one level. The right mouse button summons or banishes the menu, leaving the screen containing only the illustrator's work and a small cross-hair cursor. While in cursor mode, the mouse buttons select draw, view, or erase mode, with a corresponding (and low-key) change in cursor shape.

Small design touches take what might be mere simplicity and raise it to something approaching elegance. Selecting among a long list of saved image or screen files is done by scrolling a window vertically through a list of file names. Ordinarily, the borders of all menus are a single line. If more names exist off the top of a menu, the top border of the menu is a double line; likewise, the bottom border line of the menu doubles when items scroll off below it. Adjusting color is done by altering the height of three bars in a bar graph, with one bar for each of the primary RGB colors. At each change, all three bars take on the newly selected hue. The RGB bar graph is the only feature of EGA Paint that approaches icon status, and by being both rational and intuitive it represents the best of what an icon can and should be.

Virtually all familiar paint program functions are supported by EGA Paint. It is especially strong in two areas: pixel zoom (*fatbits*) and text manipulation. Panning the zoom window across a complicated image in realtime is a striking indicator of the program's speed. The text menu can import text from DOS files, edit the text on a 80-by-25 text screen, and display any or all parts of it in one of 32 different fonts, with underlining, reverse video, bolding, and proportional spacing as formatting options. Printer support is memory resident and can be invoked from within other programs to capture or print any EGA mode 16 screen. A simple slide show program with script file abilities is included at no extra cost.

EGA Paint departs from conventional wisdom in other ways as well. RIX has taken the bold step of eschewing the color graphics adapter market entirely. EGA Paint works *only* in EGA mode 16, 640-by-350, 16-color graphics. This assumption has allowed performance optimizations that would have been impossible on a system with installable device drivers for different modes and adapters.

EGA Paint is *fast* for such a sophisticated program. Even though the current EGA market is still small, nearly all vendors showing inexpensive EGA display boards at the Spring 1986 COMDEX show in Atlanta, Georgia, were using EGA Paint as a startling, interactive demonstration program.

Learning EGA Paint takes a little extra effort until the menu structure becomes second nature. RIX helps by providing a glossy card-stock map of the 17 menus. Eventually, the card can be set aside. In conventional paint programs, border-hugging menus are forever; EGA Paint's unconventional design allows the illustrator to decide when to draw—and when to steer.

EGA Paint: $79
RIX SoftWorks, Inc.
18552 MacArthur Blvd., Suite 470
Irvine, CA 92714
714/476-8266
CIRCLE 342 ON READER SERVICE CARD

The cover illustration and opening pages for both "The EGA Standard" (this issue, p. 48) and "The EGA Spectrum" (p. 80) were drawn with RIX's EGA Paint.

Hardware, software, and other developments for the IBM PC family

Microsoft InPort Mouse, bundled with MACH 10

National Datacomputer's DC 2.0 hand-held microcomputer

FROM IBM

IBM Corporation has announced the **Giltronix Peripheral Sharing Device Model 8007**, an RS-232 serial interface switch. The device allows as many as seven PCs to share one serial printer (such as the IBM 4201 Proprinter with serial interface, for example). This device automatically switches all necessary data to the peripheral while controlling system requests. $695.

IBM also announced that it will offer **Lucid, Inc.**'s **Common LISP** as a licensed program to run on the RT/PC under AIX 1.1. Common LISP is comprised of a development environment for creating LISP programs and a run-time environment for executing them. The product incorporates the Common LISP standard. Common LISP can interactively debug LISP programs and dynamically define and execute LISP functions and programs. Features include an extensive library of functions, special forms, macros, and an optimizing compiler and interpreter. One-time charge for the application environment, $900; the development environment, $4,000.
IBM Corporation, 900 King Street, Rye Brook, NY 10573; Contact the local IBM dealer, 800/426-2468
CIRCLE 301 ON READER SERVICE CARD

HARDWARE

A performance enhancement plug-in board has been introduced by **Microsoft Corporation**. The **MACH 10** is designed to improve the PC's ability to run the graphical user interface and multitasking features of Microsoft Windows. The MACH 10 replaces the 8088 microprocessor with a 16-bit 8086 that runs at nearly 10 MHz. A high-speed cache memory acts as a buffer between the processor and the computer's main memory. A remote speed switch permits the user to shift between the slower operating mode of the 8088 and the 10-MHz mode of the 8086. The MACH 10 board is bundled with Windows and the Microsoft InPort Mouse. $549.

Microsoft also has announced the **InPort device interface** for hardware manufacturers who want to integrate graphics input devices, such as the Microsoft Mouse, into their products. This interface scheme includes a new 40-pin custom integrated circuit and a small 9-pin connector; the chip replaces the logic circuits on the Microsoft Mouse bus board. OEM quantity pricing only; contact Microsoft.
Microsoft Corporation, 16011 N.E. 36th Way, P.O. Box 97017, Redmond, WA 98073-9717; 206/882-8080
CIRCLE 302 ON READER SERVICE CARD

National Datacomputer has introduced a hand-held, IBM-compatible microcomputer. The **Datacomputer DC 2.0** measures 11 by 4.75 by 2.25 inches and weighs 39 ounces. Key features include a rugged design, DOS compatibility, the ability to upgrade with plug-in memory boards, and data acquisition from either the keyboard or a bar code wand. The Datacomputer has an alphanumeric keyboard, liquid crystal display with two lines of 24 characters (with optional back lighting), battery power supply, and plug-in RAM boards for up to 256KB of memory. The product features an RS-232 port and can transmit data via Hayes-compatible modems or cable to computers or peripheral devices. With 128KB, $2,395; with 192KB, $2,695; with 256KB, $2,995.
National Datacomputer, 34 Linnell Circle, Billerica, MA 01821; 617/663-7677 or 7767
CIRCLE 305 ON READER SERVICE CARD

Maranatha Systems, Inc. offers a hardware companion product to Microsoft's CodeView debugger for the PC, PC/XT, and PC/AT. The **Sentinel** offloads watch-point and trace-point commands into special hardware to speed debugging. The hardware issues a trap when a preprogrammed memory location or range of locations is written to or read from, or when I/O ports are used. A special device driver makes the operation of the hardware invisible to the CodeView user. Sentinel package, including board, break-out box with break and reset buttons, software, manual, and Minibug debugger, $275. Minibug debugger, separately, including symbolic capability, a full disassembler, and 8087 support, $39.95.
Maranatha Systems, Inc., 8109 133rd Avenue NE, Redmond, WA 98052; 206/881-1068
CIRCLE 303 ON READER SERVICE CARD

The memory of the PC Convertible can be expanded to 640KB with the **C-Ram 384** memory board from **STB Systems, Inc.** This single board offers 128KB more available memory in the same space than the two 128KB RAM upgrades designed by IBM. The C-Ram 384 uses 384KB of low power consumption CMOS memory and connects directly to the installed IBM memory cards beneath the PC Convertible keyboard. $495.
STB Systems, Inc., P.O. Box 850 957, Suite 125, Richardson, TX 75085-0957; 214/234-8750
CIRCLE 304 ON READER SERVICE CARD

The **386 Translator**, a software development tool designed to help programmers use the Intel 32-bit processor, has been announced by **American Computer & Peripheral, Inc.** The 386 Translator plugs into the 80286 CPU socket of a PC/AT or compatible to transform the system into an 80386 programming environment. $395; with the 80386 chip, $895.
American Computer & Peripheral, Inc., 2720 Croddy Way, Santa Ana, CA 92704; 714/545-2004
CIRCLE 307 ON READER SERVICE CARD

TG-8000 desktop file server from Tallgrass Technologies

Banyan/DTS desktop file server

PRIAM Corporation has announced internal and external mass storage systems for the RT/PC. The **InnerSpace** family of products offers RT users a 43MB or 62MB **Internal Disk Add-In Kit** for the floor-standing IBM 6150 models 20 and 25. The **StorageSpace ED** gives the desktop IBM 6151 model 10 an external mass storage system in the same capacities. The internal drives, which include either a 43MB or 62MB 5¼-inch Winchester disk drive, optional controller, installation hardware, and interface cables, sell for $1,398 and $1,798, respectively. The ED series is packaged in a cabinet that fits beside the desktop RT and is available with hard-disk controllers to add a third drive. ED prices from $1,995 to $2,395.
PRIAM Corporation, 20 W. Montague Expressway, San Jose, CA 95134-2085; 408/946-4600
CIRCLE 314 ON READER SERVICE CARD

MetraByte Corporation's **DASH-16F** is a high-speed analog interface board for the PC, PC/XT, PC/AT, and RT/PC. DASH-16F allows 12-bit accurate analog-to-digital conversions at greater than 100,000 samples per second. The board can sample as many as 16 single-ended or 8 differential inputs. The DASH-16F also provides two channels of 12-bit accurate analog output, eight digital I/O bits, and a programmable counter/timer that can be set to control sample rates and interface to external signals. High-speed data transfers are performed using DMA (direct memory access). An assembly level software driver is supplied with the board and provides a simple interface from interpreted or compiled BASIC. Other language drivers are available. $1,095; FOR-16 FORTRAN driver, $95; CTOOLS C driver, $125; TTOOLS Turbo Pascal driver, $95.
MetraByte Corporation, 44 Myles Standish Blvd., Taunton, MA 02780; 617/880-3000
CIRCLE 318 ON READER SERVICE CARD

Support for the IBM Token-Ring Network PC Adapter and the Adapter II has been announced by **Banyan Systems Inc.** Introduced are two network server products that provide sophisticated wide area networking, host access, and server-to-server communications, as well as resource sharing for small-to-moderate-size PC clusters.

The **Banyan/DTS** is a 32-bit desktop network server that offers the full functionality of the **VINES** virtual networking system in a PC-size footprint. **VINES/286** is a software-only product that converts a conventional PC/AT into a multifunction Banyan network server. Banyan/DTS with 1MB of memory, 43MB hard disk, 60MB tape unit, support for external battery backup, VINES networking software, and diagnostics, $9,995; VINES/286, $1,895.
Banyan Systems Inc., 135 Flanders Road, Westboro, MA 01581; 617/898-2404
CIRCLE 309 ON READER SERVICE CARD

VINES virtual networking software

Tallgrass Technologies Corporation has introduced two multifunction file servers that support a variety of LAN configurations and communications options. Both use VINES virtual networking software from Banyan Systems, Inc.

The **TG-8000** is a 32-bit desktop file server that provides wide area networking, host access, and server-to-server communications, as well as resource sharing for small networks. It measures 17.1 inches high by 8.5 inches wide by 16 inches deep. With 1MB of RAM, 50MB hard disk, and 60MB tape backup, $8,495; VINES software $1,895.

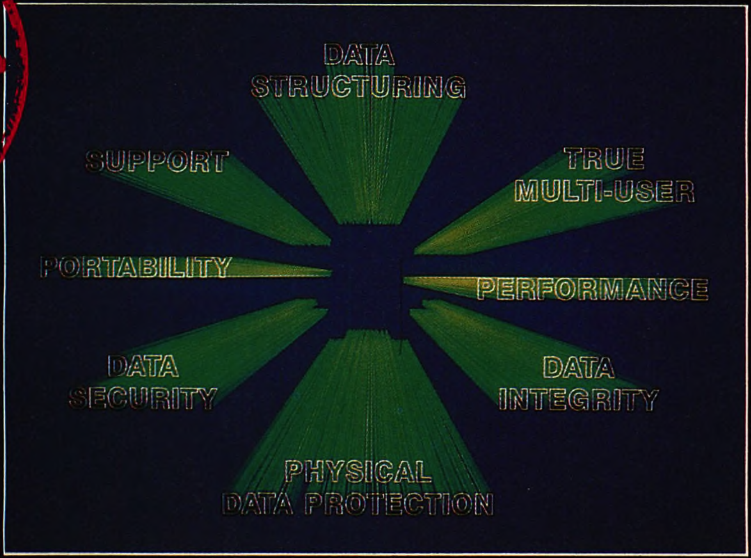
The **TG-8000AT** is a software-only version of the TG-8000, available with high-capacity disk and tape peripherals. The TG-8000AT turns a PC/AT into a multifunction network server. $1,895.
Tallgrass Technologies Corporation, 11100 W. 82nd Street, Overland Park, KS 66214; 913/492-6002
CIRCLE 308 ON READER SERVICE CARD

Previously successful on minicomputer and super-micro systems, the **Amcodyne PhD** disk storage subsystem from **Amcodyne, Inc.**, is now available for the PC, PC/XT, PC/AT, and RT/PC. The package includes an internal SCSI host adapter and software drivers, and features a 25-millisecond average access time and a 1.5MB transfer rate. The Amcodyne PhD delivers 82MB of on-line storage on three fixed disks and one removable disk. It provides unlimited database expansion via interchanging cartridges; a mirror-image backup of a 20MB volume requires only 90 seconds. The PhD system incorporates a proprietary, dynamic head-loading feature that ensures that the heads never come in contact with the disk surface. The PhD is shock resistant to 30 gs. $6,995.
Amcodyne Inc., 1301 S. Sunset Street, Longmont, CO 80501; 303/772-2601
CIRCLE 311 ON READER SERVICE CARD

From **Hercules Computer Technology** comes a graphics card that extends text capability. The **Graphic Card Plus** uses a hardware mode, called RamFont, that combines the speed and simplicity of text mode with the flexibility of graphics mode. RamFont enables application developers to design programs that can mix text and graphics on the same screen; display as many as 24 full fonts on the screen simultaneously; and display scientific and foreign language

MDBS III®

ATTN: APPLICATION DEVELOPERS



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PHYSICAL DATA PROTECTION—You get automatic recovery from media as well as from physical data destruction.

DATA SECURITY—Protect your data using passwords, encryption, and read/write access down to the field level.

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ABSOLUTE POWER

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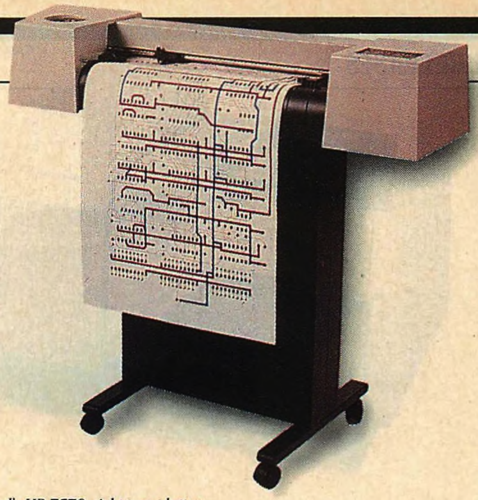
mdbs®

Toshiba's T1100 PLUS laptop microcomputer



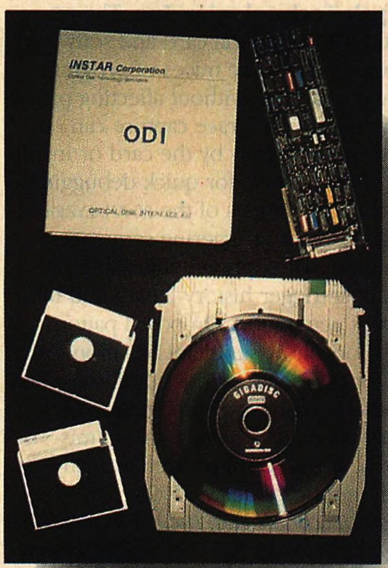
Hewlett-Packard's HP 7570 eight-pen plotter

characters, and special graphics symbols, at the speed of text mode. RamFont is made possible by the Hercules V112 video processor. The V112 chip uses a unique 12-bit character coding scheme that allows as many as 3,072 characters to be displayed at the same time. Included with the board are FontMan, a software package that helps create and edit fonts, and more than 25 sample fonts. $299.
Hercules Computer Technology, Suite 210, 2550 Ninth Street, Berkeley, CA 94710; 415/540-6000
CIRCLE 312 ON READER SERVICE CARD

Toshiba America, Inc. has released the enhanced **T1100 PLUS** portable microcomputer. This IBM-compatible laptop features two 3½-inch 720KB diskette drives, 256KB or 640KB of memory, a clock/calendar, interfaces for an RGB color monitor and monochrome composite monitor, parallel and serial ports, an optional 300/1200-baud modem, and a new keyboard layout. The PLUS has a 640-by-200-pixel, 80-character-by-25-line liquid crystal display. Equipped with a 80C86 16-bit processor operating at 7.16 MHz, the PLUS can run programs twice as fast as the PC Convertible with its 80C88 operating at 4.77 MHz (the PLUS also can run at 4.77 MHz). An I/O bus for an optional external expansion chassis with five slots is included. An optional 384KB memory card is available. The T1100 PLUS measures 12.1 by 12 by 2.6 inches and weighs less than 10 pounds. An internal NiCad battery permits up to eight hours of portable operation; an AC adapter is included. With 256KB, $1,999; with 640KB, $2,399; modem card, $399; 384KB memory card, $499; external expansion chassis, $999.

The Toshiba **T3100** is a 15-pound PC/AT-compatible portable. $4,499.
Toshiba America, Inc., Information Systems Division, 2441 Michelle Drive, Tustin, CA 92680; 714/730-5000
CIRCLE 306 ON READER SERVICE CARD

ODI-PC, an optical disk interface package from **INSTAR Corporation**, gives the PC on-line access to 1GB (gigabyte) of storage on a single removable disk. ODI-PC can be used with a WORM (write once, read many) optical disk drive to replace hard disks and magnetic tape in data-intensive applications. The ODI-PC software maintains an up-to-date directory of information on disk that permits optical disk files to be accessed randomly and modified. $1,575.
INSTAR Corporation, Suite 141, 6815 8th Street NE, Calgary, Alberta, Canada, T2E 7H7; 403/275-3143
CIRCLE 310 ON READER SERVICE CARD



INSTAR's ODI-PC optical disk interface package

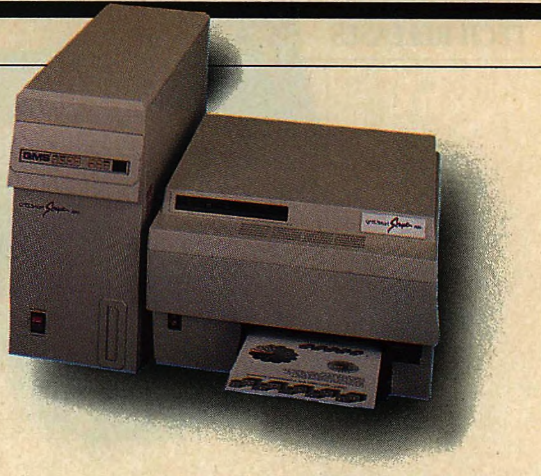
IDEAssociates, Inc. has introduced **All Aboard**, a multifunction board that includes IBM monochrome text/CGA or EGA graphics support, a disk controller that supports internal hard drives, up to 2MB of RAM available on a daughterboard, and serial and parallel ports, and a clock. With support for monochrome text/CGA, $545; and expanded memory, $745. With support for EGA graphics, $745; and expanded memory, $995.

IDEAssociates' **Overboard** is a half-length multifunction graphics adapter with serial and parallel ports, a clock, and monochrome text/CGA or EGA support. With support for monochrome/CGA, $395; for EGA, $595.
IDEAssociates, Inc., 29 Dunham Road, Billerica, MA 01821; 617/663-6878
CIRCLE 316 ON READER SERVICE CARD

The **HP DraftPro** (HP 7570), an eight-pen plotter from **Hewlett-Packard**, creates high-quality, multicolor output on architectural and engineering C/D-size and metric A1/A2-size paper, vellum, or polyester film. It features a 2-g pen acceleration, a pen speed of 15 inches per second, pen sorting, a .001-inch addressable resolution, and .2-percent linear accuracy. An RS-232 interface comes standard. $5,400.
Hewlett-Packard, P. O. Box 10301, Palo Alto, CA 94303-0890; Contact the local Hewlett-Packard dealer
CIRCLE 315 ON READER SERVICE CARD

Emulex Corporation has introduced the **ATS kit**, a subsystem that gives the PC/AT high-capacity disk storage and a cartridge streaming tape backup drive. The ATS kit offers backup storage capacities of 112MB, 146MB, or 319MB (formatted). Installation takes up just one slot and one DMA channel. Each ATS kit includes a 5¼-inch ST506 or ESDI Winchester disk drive with an Emulex MD01 or MD21 disk controller, a one-fourth-inch cartridge streaming tape drive with an Emulex MT02 tape controller, an Emulex IB02 host adapter, cables, and a mounting frame for either disk controller, along with rails to install the disk and tape drive peripherals into the AT. Prices range from $6,175 to $11,100.
Emulex Corporation, 3545 Harbor Blvd., P. O. Box 6725, Costa Mesa, CA 92626; 800/EMULEX3; in California, 714/662-5600
CIRCLE 313 ON READER SERVICE CARD

QMS Lasergrafix 1500



QMS SmartScript 800

Alloy Computer Products, Inc. has announced a storage subsystem that allows data exchange between the PC Convertible and the PC, while also providing mass storage for the laptop. **StarBase-III** includes a 360KB 5¼-inch floppy-disk drive, a 20MB Winchester drive, a 40MB 3½-inch cartridge tape backup unit, and a parallel printer port. The floppy-disk and Winchester drives function as additional drives on the Convertible. Users can run programs or access data directly from these drives or use DOS commands to copy files between them and the Convertible's 3½-inch floppy diskettes.

ClusterNET from Alloy is an 80286-based subsystem designed to function as a high-performance engine in multiuser clusters. ClusterNET incorporates an 80286 processor running at 10 Mhz, a 360KB floppy-disk drive, Winchester disk storage of up to 380MB, cartridge tape backup of 120MB, up to 8MB of RAM-based disk cache, expansion slots to accommodate as many as 16 users, ports for peripherals, a power supply, and system software. ClusterNET's Winchester drives have average access times of less than 30 milliseconds. Prices not available.

Alloy Computer Products, Inc., 100 Pennsylvania Avenue, Framingham, MA 01701; 617/875-6100

CIRCLE 317 ON READER SERVICE CARD

Four laser printers have been introduced by **QMS, Inc.** The **QMS SmartScript 800** is a laser printer that performs like a QMS SmartWriter for business use with text and graphics or as a QMS PS to support the PostScript page description language for desktop publishing applications. It operates at eight pages per minute (ppm). $8,995.

The **QMS PS-2400** is a 24-ppm laser with 13 fonts and PostScript support. It has a print resolution of 90,000 dots per square inch and a duty cycle of 30,000 prints per month. $29,995.

The **Lasergrafix 1500**, a 15-ppm, full-page bit-map laser is designed for printing sophisticated text and graphics. It offers resolution of 90,000 dots per square inch and has a duty cycle of 25,000 prints per month. $11,995.

The **SmartWriter 150** is a 15-ppm enhanced version of the SmartWriter with 19 resident fonts; its duty cycle is 25,000 prints per month. $6,995.

QMS, Inc., P.O. Box 81250, Mobile, AL 36689; 205/633-4300

CIRCLE 321 ON READER SERVICE CARD

A hardware/software package for realtime debugging has been announced by **Sofpak Technologies, Inc.** The **PC-ANALYZER** peripheral card and software monitors and store traces of program flow in realtime, without affecting program execution. Trace capture can be done automatically by the card or manually with a switch, for quick debugging. Tracing capabilities of the PC-ANALYZER include two-level triggering sequences, qualified store options, adjustable pre- and post-trigger history length and interrupt generation. On-board pattern detectors allow simultaneous monitoring for two separate bus conditions. Bus conditions can be a combination of address range, data pattern match/mismatch, and CPU status, with as many as 2,047 multipass delays. $995.

Sofpak Technologies, Inc., Moodie Drive High Tech Park, 105-215 Stafford Road, Ottawa, Canada K2H 9C1; 613/726-1908

CIRCLE 319 ON READER SERVICE CARD

An IBM-compatible token-ring network has been introduced by **Ungermann-Bass, Inc.** The **Net/One Token Ring** is an IEEE 802.5-compatible system that includes server support for hosts, asynchronous and IBM 3270-PC terminals, printers, and modems; workstation support for devices based on the IBM PC bus; and distributed wiring concentrator (DWC) support. Acting as a network hub, the DWC allows as many as 10 IEEE 802.5 network interface units (NIUs) to be connected to the network. Net/One Token Ring provides network management in a multiple-ring environment, with connectivity provided via Net/One Ring-to-Ring Bridges. The system supports both the NETBIOS and MS-NET interfaces. Personal NIU, $895; DWC, $1,000; Ring-to-Ring Bridge, $8,995; NIU 180/Token Ring (asynchronous terminal server), $3,600.

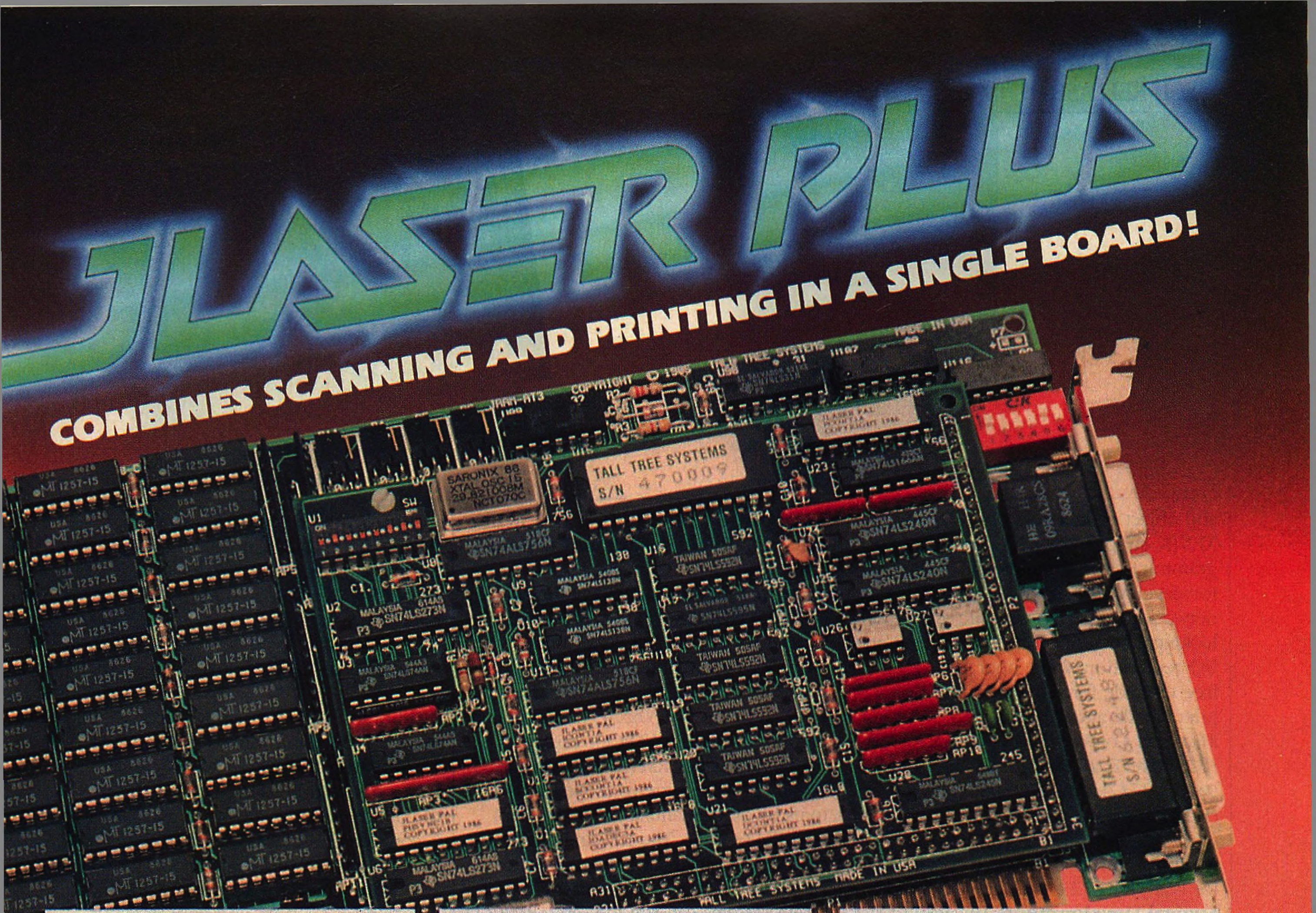
Ungermann-Bass, Inc., 3900 Freedom Circle, Santa Clara, CA 95052-8030; 408/496-0111

CIRCLE 320 ON READER SERVICE CARD

SOFTWARE

Microsoft Corporation has announced **QuickBASIC 2.0**, a BASIC compiler with in-memory compilation and pull-down menu operation. It allows programmers to write, compile, and debug structured and modular programs without leaving the programming environment. Some of the features include an interactive full-screen editor, interactive error detection and correction, and intelligent linking. $99; free update for previous versions purchased after May 15, 1986; $30 to update versions purchased prior to that date.

Also announced by Microsoft is the **C Compiler version 4.0**. Enhancements include improved optimization that allows the user to generate faster, more compact programs, as well as a complete development toolkit. An important part of the toolkit is **CodeView**, a window-oriented debugger that lets the programmer examine CPU registers and flags as well as memory while a program is running. By opening windows as needed, the user can view source code, object code, or both as the program is being executed. Other features include libraries compatible with UNIX System V, portability of source




Recipe for
DESKTOP PUBLISHING DELIGHT

Main Ingredient:
1 JLASER PLUS (EMS memory board with combination printer/scanner interface)

Other Ingredients:
1 PC, XT, or AT style desktop personal computer
1 Canon-based 300 DPI laser printer
1 Canon IX-12 300 DPI scanner
Connecting cables
4 Banks of 256K RAM chips minimum. Total of 8 banks is optional if you like extra chips.
1 or more software programs that support JLASER or JLASER PLUS.

Directions:
Install JLASER PLUS with RAM chips in a single slot of the computer. Hook up scanner and laser printer with cables. Install desired software packages. Scan pictures of graphics. Mix with text and print out tasteful, professional-looking documents, newsletters, and graphic designs at full 300 DPI resolution and maximum speed.

Combined scanning and printing with JLASER PLUS. It lets you have your cake and eat it too.

Desktop publishing can be a piece of cake when you have the right ingredients. The quality of the ingredients will make all the difference. Don't be fooled by high-priced substitutes. Follow our recipe exactly. You'll be delighted with the results.

It makes desktop publishing a piece of cake!

Tall Tree Systems introduces another breakthrough in desktop publishing with JLASER PLUS. We've combined a 2 MB EMS memory board and an interface to both a Canon®-based laser printer and scanner. JLASER PLUS increases the performance of both devices and gives you a low-cost solution to the limitations you've been experiencing with them.

Furthermore, the same memory that is made available to your printer and scanner is also available for all your other conventional applications. You get system memory, expanded LIM memory, extended memory in an AT-type machine, RAM Disk and print spooler — all in a single slot!

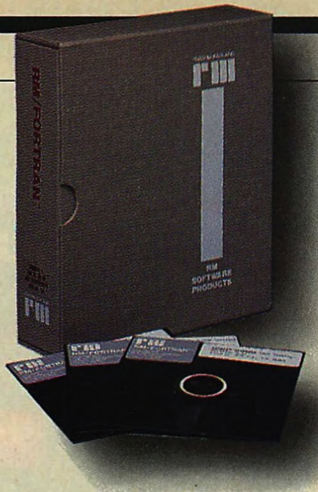
Supporting JLASER PLUS is a host of software packages, such as PC Paintbrush + from ZSoft, Dr. Halo D.P.E. from Media Cybernetics, LaserGL from Software Express, Ventura Publisher from Xerox, Page Builder from White Sciences, Le Print from Le Baugh Software, Fancy Font and Fancy Word from SoftCraft, Inc., and many more to be announced.

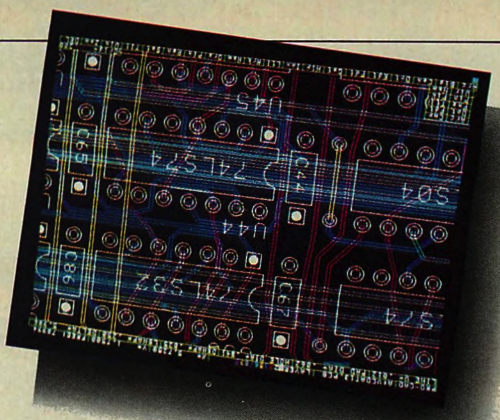
It takes a technological innovator like Tall Tree Systems to provide a major advancement like JLASER PLUS. And we don't stop at performance. We also deliver value, which is truly icing on the cake.

TALL TREE SYSTEMS
1120 San Antonio Road
Palo Alto, CA 94303
(415) 964-1980

CIRCLE NO. 194 ON READER SERVICE CARD

TALL TREE SYSTEMS


RM/FORTRAN version 2.1 released by Ryan-McFarland


PROCAD screen, by Electronic Design Tools

and object code across MS-DOS and XENIX, support for mixed-language programming, start-up and exit source code for developing ROMable C programs, network file sharing with file and record locking, and support for path names and I/O redirection. $450; upgrade, $150; free upgrade for purchases of C Compilers made after June 1, 1986.
Microsoft Corporation, 16011 N.E. 36th, P.O. Box 97017, Redmond, WA 98073-9717; 206/882-8080
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A Ratfor translator designed specifically for FORTRAN-77 compilers is offered by **Logical Developments**.The **RF77** features full use of DOS 2.x file capabilities, including redirection, piping, and hierarchical directories; an **include** command that allows multiple external file merging (included files may be nested); adjustable line widths; and a provision for verbatim output for nonstandard lines. $65.
Logical Developments, P.O. Box 55798, Houston, TX 77255; 800/835-2246, ext. 41
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Phoenix Technologies, Ltd. and **INTERACTIVE Systems Corporation** are jointly developing system software to provide OEMs with a virtual PC environment under the recently announced UNIX System V version 3.0 for computers based on Intel's 80386 microprocessor. Internally named **V86/ix**, the product will permit users of 80386-based systems to run a PC-compatible DOS application as a task under UNIX without modification.
Phoenix Technologies, Inc., 320 Norwood Park South, Norwood, MA 02062; 617/769-7020
CIRCLE 325 ON READER SERVICE CARD
INTERACTIVE Systems Corporation, 2401 Colorado Avenue, Santa Monica, CA 90404; 213/453-8649
CIRCLE 326 ON READER SERVICE CARD

RM/COBOL for the RT/PC is now available from **Ryan-McFarland Corporation**. RM/COBOL is a GSA-certified, error-free implementation of the ANSI X3.23 74 COBOL standard. It is available for the PC, PC/XT, and PC/AT under DOS; for the AT under XENIX; the IBM System/36 under SSP; the Series 1 under UNIX; and the 370/30xx/43xx mainframe architecture under VM/CMS.Software developed under RM/COBOL can run on any of these systems as well as systems by other manufacturers that support RM/COBOL. The RT can be used to develop and maintain applications for various machines. In most cases the different systems can run the same RM/COBOL object code; in all cases they run the same source code. $1,250.

Ryan-McFarland also has introduced **RM/FORTRAN level 2.1** for DOS-based PCs. RM/FORTRAN is a mainframe FORTRAN compiler that runs on 16-bit microcomputers. Enhancements for the version 2.1 include the COMPLEX*16 data type, mixed characters and numerics in COMMON and EQUIVALENCE statements, and a simplified interface for assembly language routines. RM/FORTRAN is a full implementation of FORTRAN-77 and is GSA certified error-free at the highest level. $595.
Ryan-McFarland Corporation, 609 Deep Valley Drive, Rolling Hills Estates, CA 90274; 213/541-4828
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A full-featured CAD package, **PROCAD**, has been announced by **Electronic Design Tools, Inc.** PROCAD provides engineers with a powerful tool for the creation of integrated circuits, hybrid devices, and printed circuit boards (PCBs). As a drafting system, PROCAD handles the electronic circuit from the conceptual schematic stage through a camera-ready drawing of the completed PCB. As a database, PROCAD contains the logical, physical, and electrical specifications for designs as well as all the necessary information for the design, manufacturing, testing, purchasing, and support of an electrical assembly. $2,500.
Electronic Design Tools, Inc., 1509 Falcon Street, Suite 103, DeSoto, TX 75115; 214/224-2472
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A C library support package, **C TOOLS PLUS**, has been introduced by **Blaise Computing Inc.** C TOOLS PLUS offers a series of functions designed specifically to complement the Microsoft and Lattice C compilers. Features include fast and flexible screen handling, support for the IBM EGA, window management, multiple monitor support, and improved interrupt service routine support allowing resident utilities to be built easily. C TOOLS PLUS is shipped with all source code, sample programs, and a manual. No additional royalties are required to incorporate C TOOLS PLUS functions into developed applications. $175.
Blaise Computing Inc., 2560 Ninth Street, Suite 316, Berkeley, CA 94710; 415/540-5441
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Numerical Algorithms Group has announced the **NAG FORTRAN Library** for the RT/PC. The Library is a comprehensive mathematical and statistical library used worldwide on systems ranging from workstations to super computers. It includes 525 FORTRAN-callable routines for developing application programs in computational science and engineering. Areas covered include fast Fourier transforms, linear algebra, ordinary differential equations, numerical integration, linear and nonlinear optimization, curve and surface fitting, and statistics. Annual lease for the RT library, $1,300; perpetual license with optional maintenance support, $3,900.
Numerical Algorithms Group, 1101 31st Street, Suite 100, Downers Grove, IL 60515-1263; 312/971-2337
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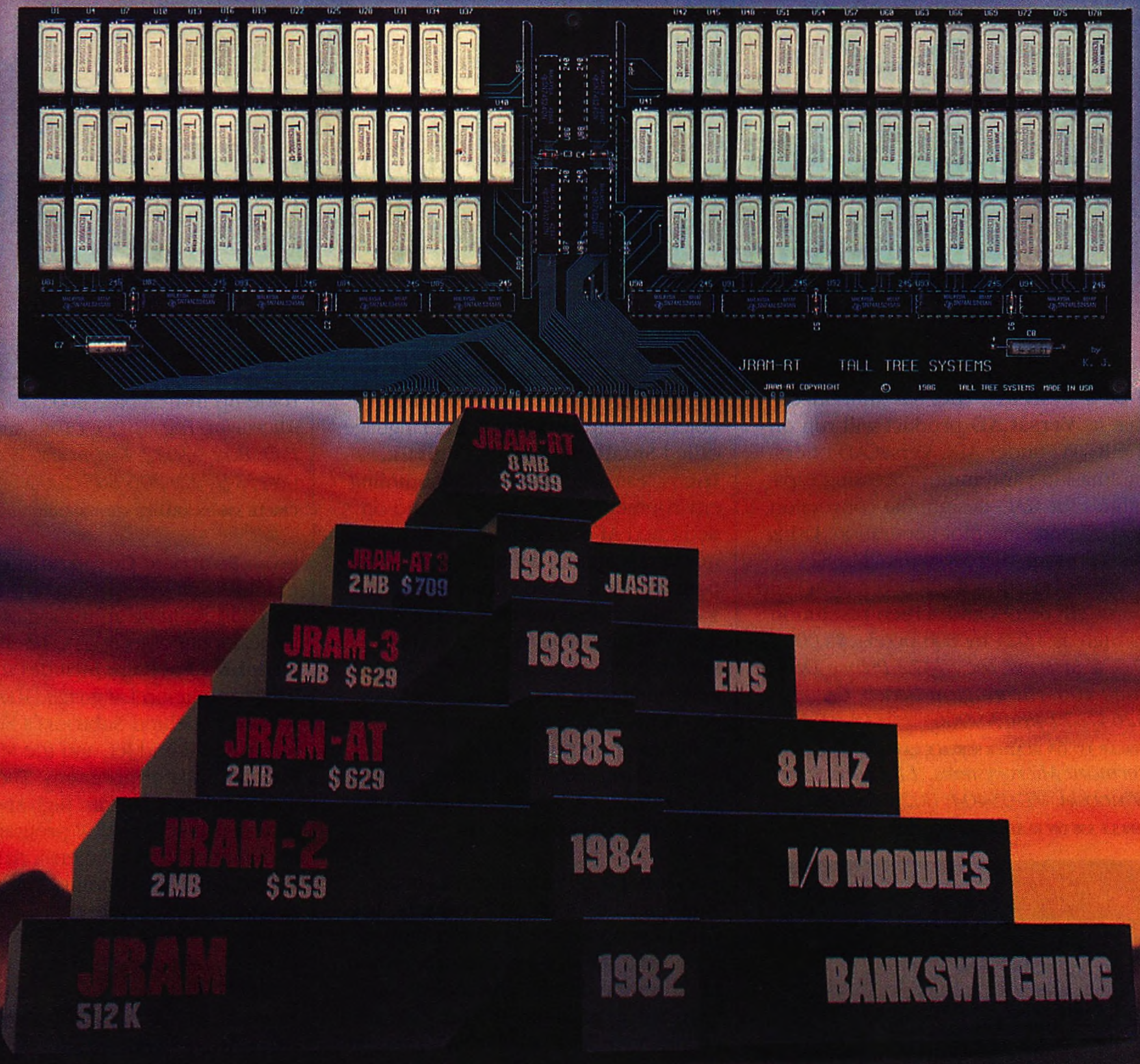

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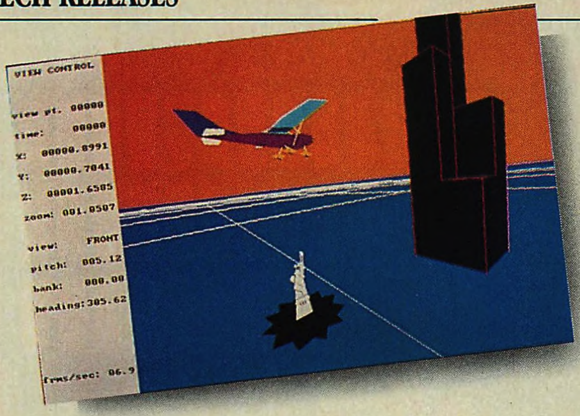
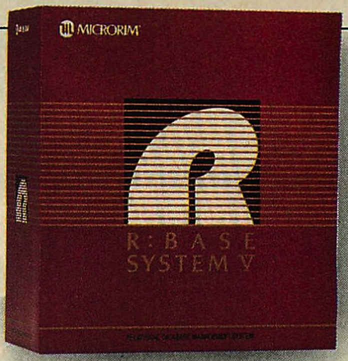


IB-3D1 3D screen, by SubLOGIC



R:base System V from Microrim, Inc.

T & W Systems, Inc. has announced that its **VersaCAD** product will run on the RT/PC under AIX. VersaCAD offers multitasking and multiprocessing capabilities for CAD design, file conversion, text editing, and plot generation. Using the Vermont Microsystems VM 8825 graphics board in the RT, VersaCAD supports 256 colors and screen resolution as high as 1,024 by 800 pixels. $4,000.
T & W Systems, Inc., 7372 Prince Drive, Suite 106, Huntington Beach, CA 92647; 714/847-9960
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Vermont Microsystems, 11 Tigan Street, Winooski, VT 05404; 802/655-2860
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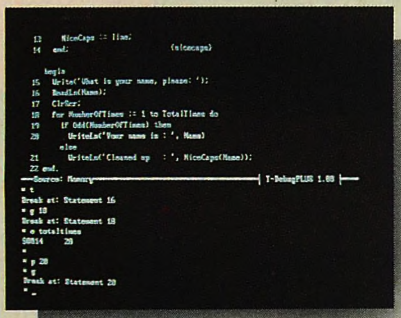

TDebugPLUS screen, from TurboPower Software

A runtime symbolic debugger for Turbo Pascal, **TDebugPLUS** from **Turbo-Power Software**, enables programmers to trace, set breakpoints, and examine and set variables at runtime, using the symbolic variable names from their Pascal source code. T*Debug*PLUS automatically loads Turbo Pascal for normal editing and compiling. After the program has compiled correctly, T*Debug*PLUS displays source code on one-half of the screen and debugging commands and responses on the other half. $60.
TurboPower Software, 478 W. Hamilton Avenue, Suite 196, Campbell, CA 95008; 800/538-8157, ext. 830; in California, 800/672-3470, ext. 830; 408/378-3672
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An implementation of the Smalltalk object-oriented programming language, called **Smalltalk/V**, from **Digitalk, Inc.**, creates a graphical programming environment similar to that found on dedicated AI workstations. Featuring bit-mapped graphics, windows, mouse support, a built-in Prolog compiler, object-swapping virtual memory, and a sophisticated source-level debugger, the system encourages an exploratory programming style for solving complex problems as well as prototyping complex applications. $99.
Digitalk, Inc., 5200 W. Century Blvd., Los Angeles, CA 90045; 213/645-1082
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Version 1.4 of **WATFOR-77** has been announced by **WATCOM Products, Inc.** One new option causes the compiler to produce a stand-alone executable module from the developer's application program, maintaining the one-step procedure to process a FORTRAN program. Version 1.4 permits direct loading of object files. In addition, WATCOM has developed the Graphical Kernel System (GKS level 0a) subroutine library for use with WATFOR-77. $375.
WATCOM Products, Inc., 415 Phillip Street, Waterloo, Ontario, Canada N2L 3X2; 519/884-2700
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R:base System V from **Microrim, Inc.** is a database for stand-alone or multi-user LAN environments. It provides menu-driven capabilities for querying, sorting, and reporting of data. R:base System V has a relational DBMS that includes a high-level procedural language. A data dictionary tracks all columns and their locations, and developers can encrypt application code. R:base System V provides a set of 70 mathematical and financial functions, as well as powerful string manipulations and data conversion. $700, with no additional DBMS costs for added workstations on LANs; trade-up from R:base 5000, $99.
Microrim, Inc., 3925 159th Avenue NE, P.O. Box 97022, Redmond, WA 98052-9722: 206/885-2000
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From **SubLOGIC Corporation** comes a graphics software package for the creation and realtime animation of three-dimensional objects. The **IB-3D1 3D Graphics Package** includes the Real-Time Animation Language (RTAL) graphic drivers behind SubLOGIC's Flight Simulator II and Jet, and the Microsoft Flight Simulator programs. The package also contains a custom high-speed assembler/linker, a VIEW program to view and animate three-dimensional databases, and a self-running demonstration program with sample database. $995.
SubLOGIC Corporation, 713 Edgebrook Drive, Champaign, IL 61820; 800/637-4983 (except Alaska and Hawaii); in Illinois, 217/359-8482
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OTHERWARE

R.R. Bowker has introduced electronic versions of its two most popular library references, *Books in Print (BIP)* and *Ulrich's International Periodicals Directory*. Called **BIP Plus** and **Ulrich's Plus**, the two are offered on CD-ROM. The software that comes with the CD-ROM lets the user search all five *BIP* publications by author, key word, publisher, subject, title, edition, audience, language, price, and publication date. Subscription rates for BIP Plus, $895; for Ulrich's Plus, $395.
R. R. Bowker, 205 E. 42nd Street, New York, NY 10017; 212/916-1600
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Rapitech's translation package is a shining example of translation technology at its best. Programmers on VAX, Fortune, Sun and other systems already know that FORTRIX-C+ produces standard K&R C from Fortran-77 code. It handles IMPLICIT, COMMON, and EQUIVALENCE statements, typically (for I/O-bound programs) runs 15-30% faster and produces 35% smaller load modules. Benchmarks show that FORTRIX-C+ code and hand-coded FORTRAN source run at equivalent speeds overall.

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DAN ROLLINS

Visible RAM Disk

VDISK.SYS can be patched to provide visible notification of RAM disk activity.

A RAM disk can boost productivity, especially when used for storing frequently used utility programs and code overlays. As a temporary scratch disk, it is a great place for intermediate compiler files to avoid disk thrashing. RAM disks, however, generally lack an essential feature found in every diskette drive—a read/write indicator light.

Patching VDISK.SYS to remedy this omission is a good exercise in working with device drivers and in using DEBUG to patch existing software. To install the patch, DEBUG and VDISK.SYS (version 2.0) must be on the same diskette or directory. The user first invokes DEBUG VDISK.SYS. At the DEBUG prompt, enter the command **D 400**. At address 427 a section appears with the repeated string PATCH AREA; enter the command **U 1D4 210**, which shows the entrance and exit codes of the device driver's strategy routine.

Next, enter the commands shown in the accompanying figure beginning with the command **A 1d9**. If desired, a text file called PATCH.SI can be created that contains the commands exactly as shown, including the blank lines. (The comments may be deleted.) Then execute the patch all at once with the DOS command DEBUG < PATCH.SI.

The patch area contains 56 bytes; the patch code occupies 55 bytes. The patch replaces several opcodes of the main line with a jump, executes duplicates of those opcodes, does its work, then jumps back to the main line. This sequence is used in the entrance and exit portions of the main line.

The entrance code sequence finds which type of monitor is active and uses that information to determine the segment address of video RAM. It then saves the first four bytes of video memory—the two character/attribute pairs in the upper left corner of the display—and replaces them with two reverse video characters. Finally, the sequence saves the video memory segment and returns to the main line. Thus, at entry to the device driver, two characters are displayed on the first two positions of the screen.

Upon exit, the patch first fetches the saved video segment and then goes into a delay loop. It simply counts down from 500H to 0. This provides enough time to make sure that the drive light is visible for at least part of a screen refresh cycle. After this delay, it restores the previous screen bytes, executes the opcodes overlaid by the patch jump, and returns to the main line. Just before exiting the RAM disk driver, the screen is restored to its original display.

The display delay can be shortened so it will not decrease the speed of the RAM disk. Do not set the value to 0, however. In order to eliminate the delay entirely, simply remove the **loop 450** line from the patch.

After the patch is installed, a new device driver called VISVDISK.SYS appears. Install it using the **device=** configuration command format in the DOS reference manual.

FIGURE: *Patching VDISK.SYS*

```
N vdisk.sys
L
A 1d9
jmp 427

A 427
push dx                     ;execute the opcodes
push di                     ; overlaid by
push si                     ;  the patch jump
int 11                      ;determine video memory segment
mov bx,b800                 ; -- default is color card
and al,30                   ; get card-type bits
cmp al,30                   ; monochrome card?
jne 437                     ;   no, continue
mov bh,b0                   ;   yes, segment is B000h
mov ds,bx                   ;enable vidmem addressing
sub si,si                   ;point to top left corner
push [si]                   ;save current contents
push [si+2]
mov word ptr [si],7011      ;70 is reverse video
mov word ptr [si+2],7010    ;11 and 10 are chars
push ds                     ;save video segment for exit
jmp 1dc                     ;return to mainline code

A 208
jmp 44d                     ;set the exit patch

A 44d
pop ds                      ;get video memory segment
mov ch,5                    ;time delay so the
loop 450                    ; light is visible
sub si,si
pop [si+2]                  ;restore previous
pop [si]                    ; screen bytes
pop si                      ;execute the opcodes
pop di                      ; overlaid by
pop dx                      ;  the patch jump
jmp 20b                     ;return to mainline code

n visvdisk.sys
w
q
```

Some caveats must be kept in mind when using the modified driver. It works no matter which mode the display is in; however, the drive light will be invisible on a color monitor if it is displaying any but the first screen page. In graphics mode, the drive light is displayed as a few random dots in the top left corner. Further, a BASIC application that BLOADs or BSAVEs video memory should not read or write such screen images to the RAM disk.

Dan Rollins is a PC consultant and freelance technical writer who lives in California. He is the author of IBM PC: 8088 Macro Assembler Programming *published in 1985 by Macmillan.*

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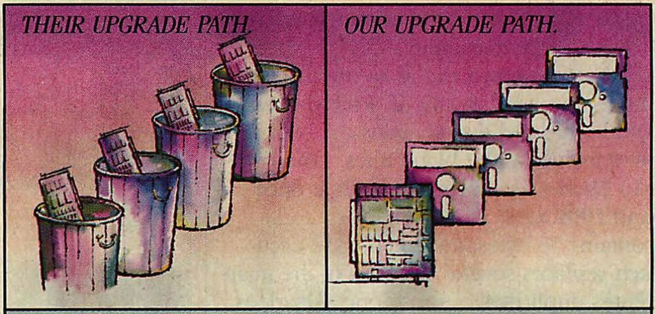

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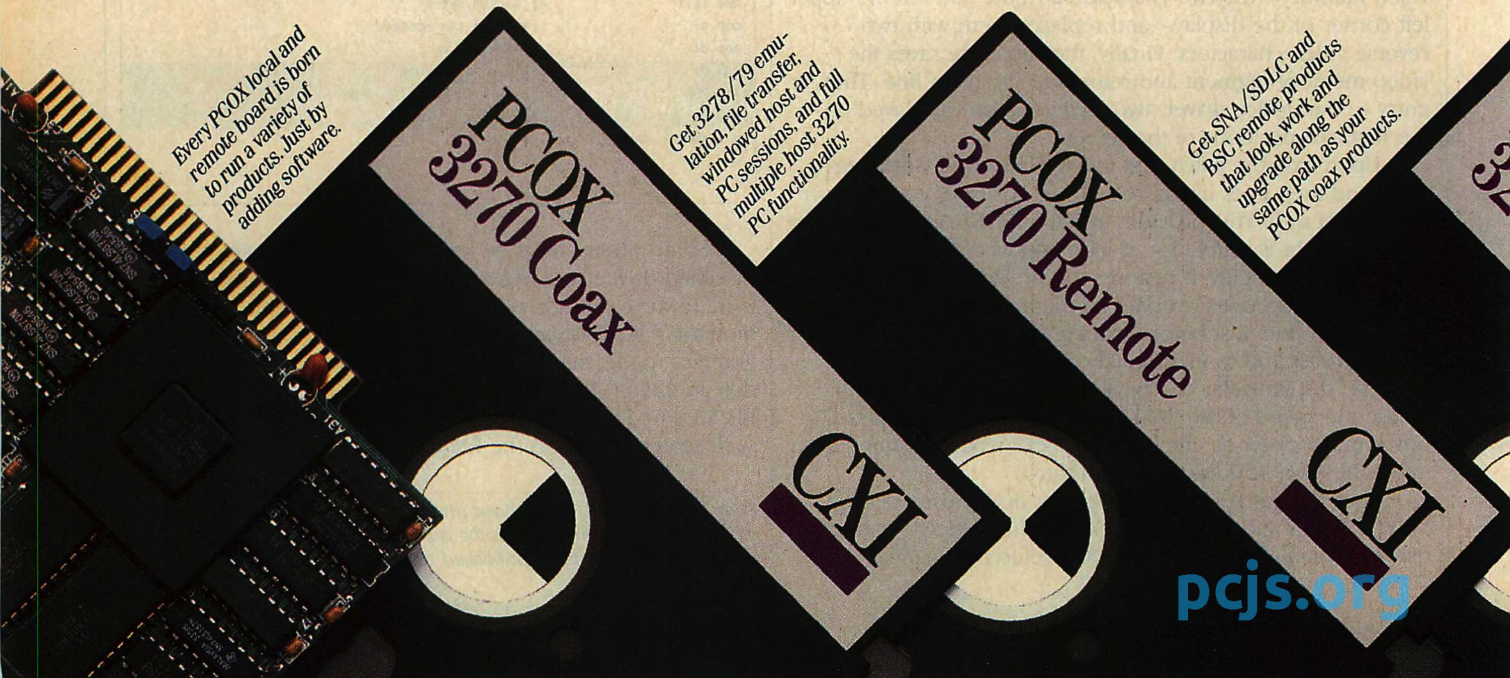

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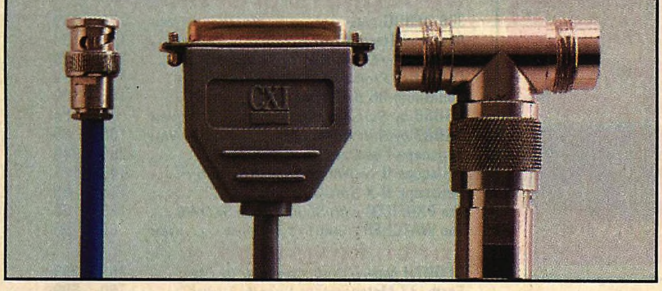

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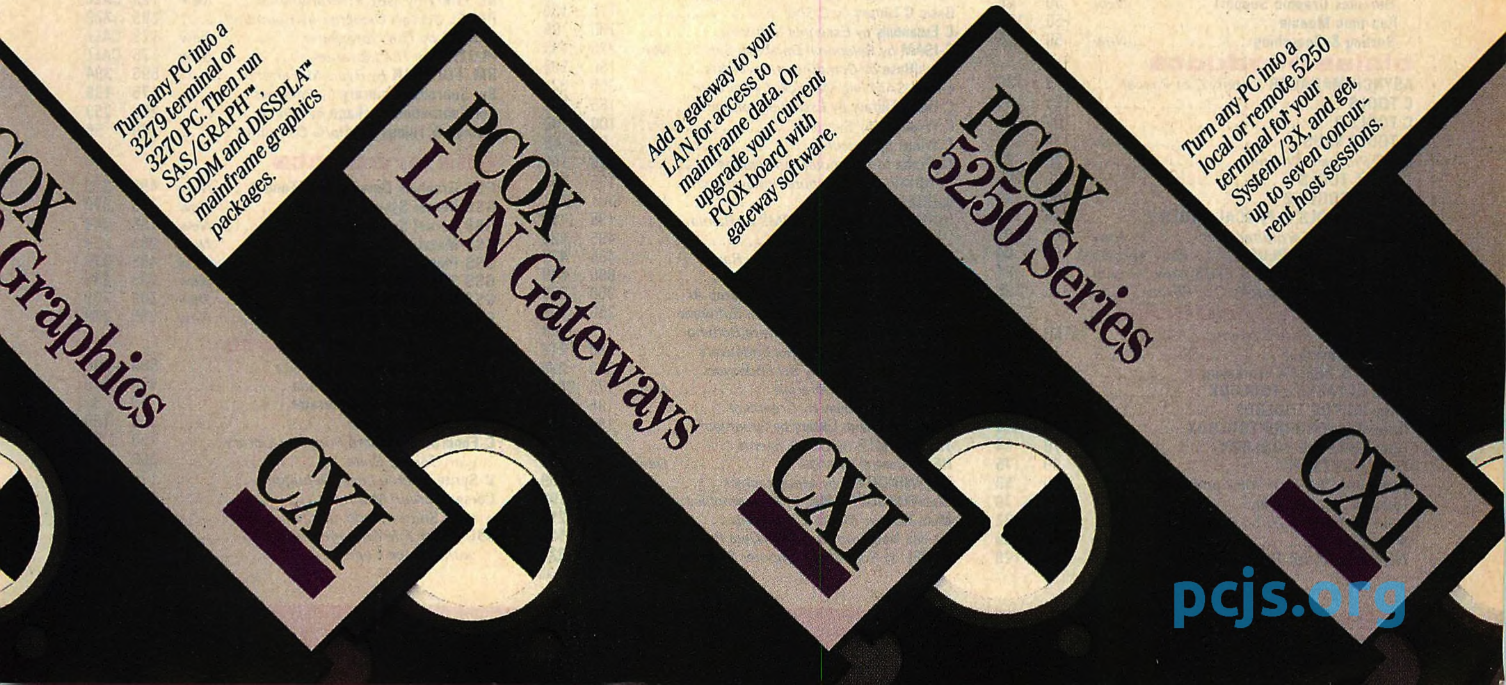

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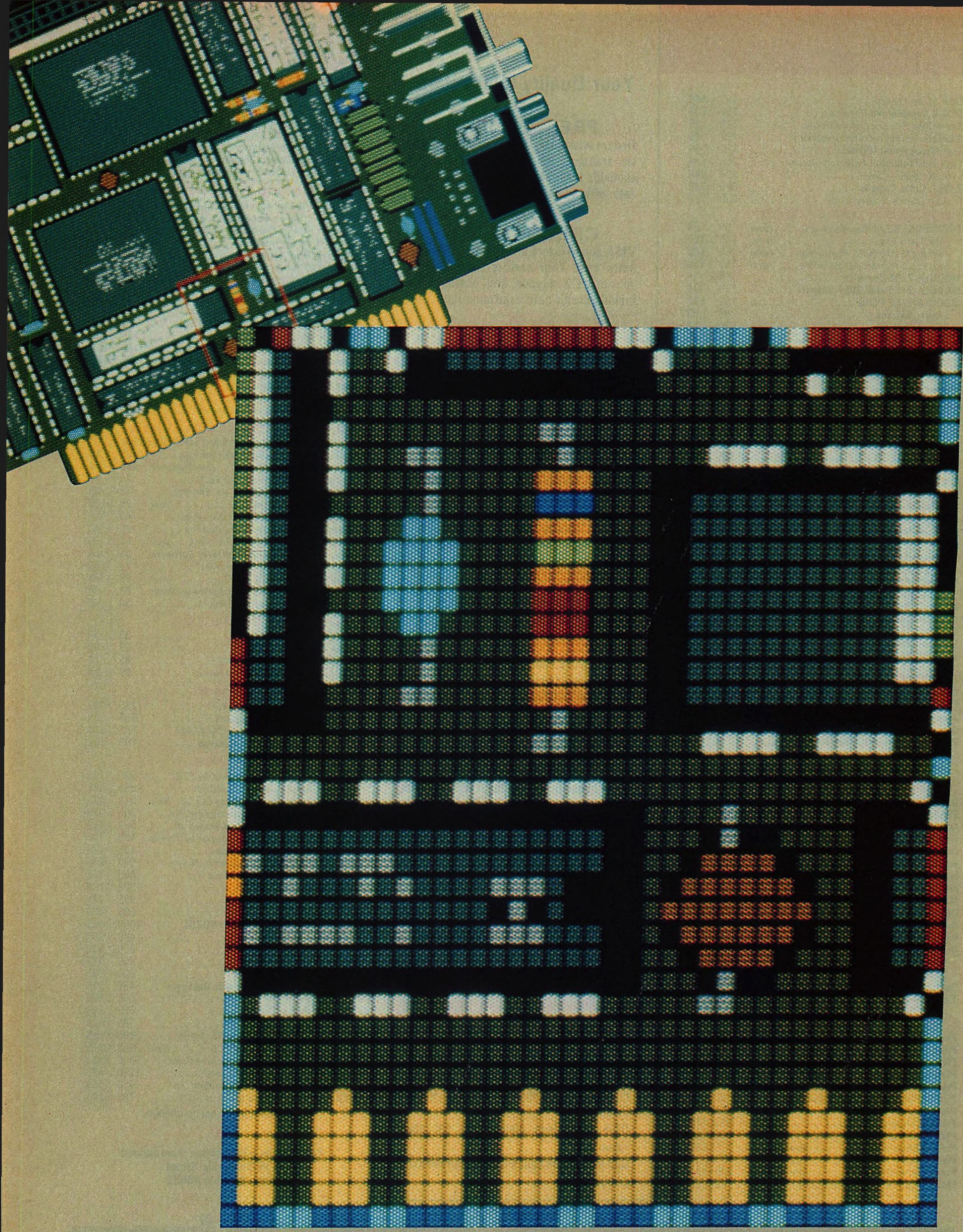

The EGA Standard

Introduced two years ago, the IBM EGA has become a standard for enhanced graphics boards. PC Tech Journal reviews the EGA technology and devises a series of tests to judge EGA compatibles.

JOHN T. COCKERHAM

Beneath the dazzle of the IBM Enhanced Graphics Adapter (EGA) standard lies a perplexing web of hidden detail. IBM's board is known less for what it is than for what it is not: *not* fully downward compatible with the IBM Color Graphics Adapter (CGA); *not* capable of composite video output; *not* cheap; and *not* understood by the majority of software developers.

IBM's technical documentation for the EGA was late in coming, contained numerous errors, and has been hard to obtain. For this and other reasons, developers have been slow to write for the EGA's full complement of features.

In recent months, however, an explosion of inexpensive EGA-compatible graphics adapters has sent developer interest in the EGA through the stratosphere. *PC Tech Journal* was early on the scene with technical information about the EGA when the IBM board was the only implementation (see "Graphic Enhancement," Thomas V. Hoffmann, April 1985, p. 58).

Today, with 18 additional months of experience and nearly two dozen compatible boards on the market, the time has come to review the operation of the EGA and answer some serious questions about the measurement of compatibility with the IBM standard. In the article immediately following this one ("The EGA Spectrum," John T. Cockerham, p. 80) and in its continuation next month, several of the new EGA compatibles are reviewed.

Before examining compatibility issues, a discussion of the EGA functional anatomy is in order. The EGA hardware is a memory-mapped device based on video display RAM (64KB to 256KB) organized into four parallel bit planes. In the native EGA modes, all four planes lie within the same 64KB memory range, which can be mapped by the hardware to different CPU addresses depending on the mode. CGA-compatible graphics modes, for example, are mapped at B800H, while the 640-by-350 graphics modes are mapped at A000H. Plane mapping in CGA and monochrome display text modes is not as simple, because the planes must be interleaved in order to support earlier character/attribute buffer structures.

Unlike the CGA, EGA video RAM can be accessed at any time without causing visual interference; this is due to the arbitration logic built into the EGA's timing sequencer. If the EGA and the CPU both try to access video RAM at the same time, the sequencer holds the CPU until the EGA finishes. In 40-by-25 text modes the sequencer grants the CPU three out of five accesses. In 80-by-25 text modes and high-resolution graphics modes, when the EGA needs greater access to the video RAM, the CPU receives only one out of five accesses. The impact of these limits on perceived program speed is lessened by the fact that access to video RAM is generally a very small part of the overall program code.

The IBM EGA uses 4416 RAM chips that are organized into 16K-by-4 bits for

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video RAM. The compatibles tested in this series use 64K-by-4 RAM chips.

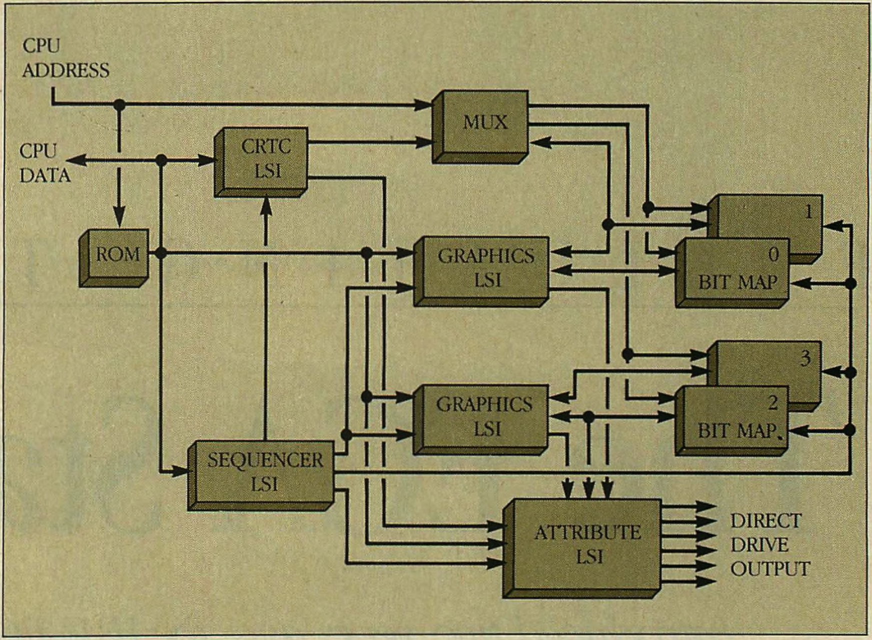
HARDWARE ARCHITECTURE

Many I/O registers in the EGA do multiple duty by way of *index values*. An index value must be written to an *address register* to select the desired value from the several available through that register. The value returned is then read from the *data register*, which may or may not be the same as the address register. For example, the CRT controller uses an address register of 3B4 and a data register of 3B5 (or 3D4 and 3D5 at the alternate I/O address), but the attribute controller uses 3C0 for both the address and the data registers. A complete list of I/O register assignments is provided in the April 1985 review, "Graphic Enhancement."

The EGA does not use Motorola's 6845 CRT Controller, as do IBM's CGA and Monochrome Display and Printer Adapter. Instead, IBM designed several custom large-scale integration chips—the timing sequencer, two graphics controllers, the attribute controller (ATC), and the CRT controller (CRTC)—that communicate with the CPU by way of I/O ports (see figure 1). The timing sequencer's address register lies at 3C4H with its data register at 3C5H. The two graphics controllers share address registers at 3CEH and data registers at 3CFH, with each controller managing two of the four bit planes simultaneously—in fact, acting as parallel processors. The ATC's address and data registers are both mapped at 3C0H, and a CRTC is situated at 3B4 (address) / 3B5H (data) for monochrome modes or 3D4 / 3D5H for color modes. One of the hardware status registers (3xAH) follows the CRTC address and has the same semantical layout as status registers for the earlier IBM display adapters, allowing all pre-EGA software to operate without any modification.

The CRTC takes all timings from a 16.257-MHz on-board crystal oscillator for all modes requiring 350 vertical scan lines or from the 14.318-MHz dot clock located on the CPU motherboard for 200-scan-line modes. With each tick of the dot clock, the video drivers shift out (send) one pixel's worth of video information over the six parallel color lines to the monitor. Every eight dot clocks count as a character clock except in mode 7 (which is identical to the monochrome display adapter's 25-by-80 alpha mode) in which nine dot clocks count as a character clock because of the 9-by-14 character block. With each character clock the CRTC directs the other video chips to fetch the next byte of data from video RAM.

FIGURE 1: *EGA Architecture*



IBM's original EGA implements the major functions shown here (outside of ROM and video RAM) in five custom LSI chips. The current Chips & Technologies chip set cuts that to four chips, while several other manufacturers implement the full EGA—and often the CGA, monochrome adapter, and Hercules Graphics Card as well—on only a single chip. C&T has announced a single chip implementation of its current four-chip set, to be available late this year or early next year.

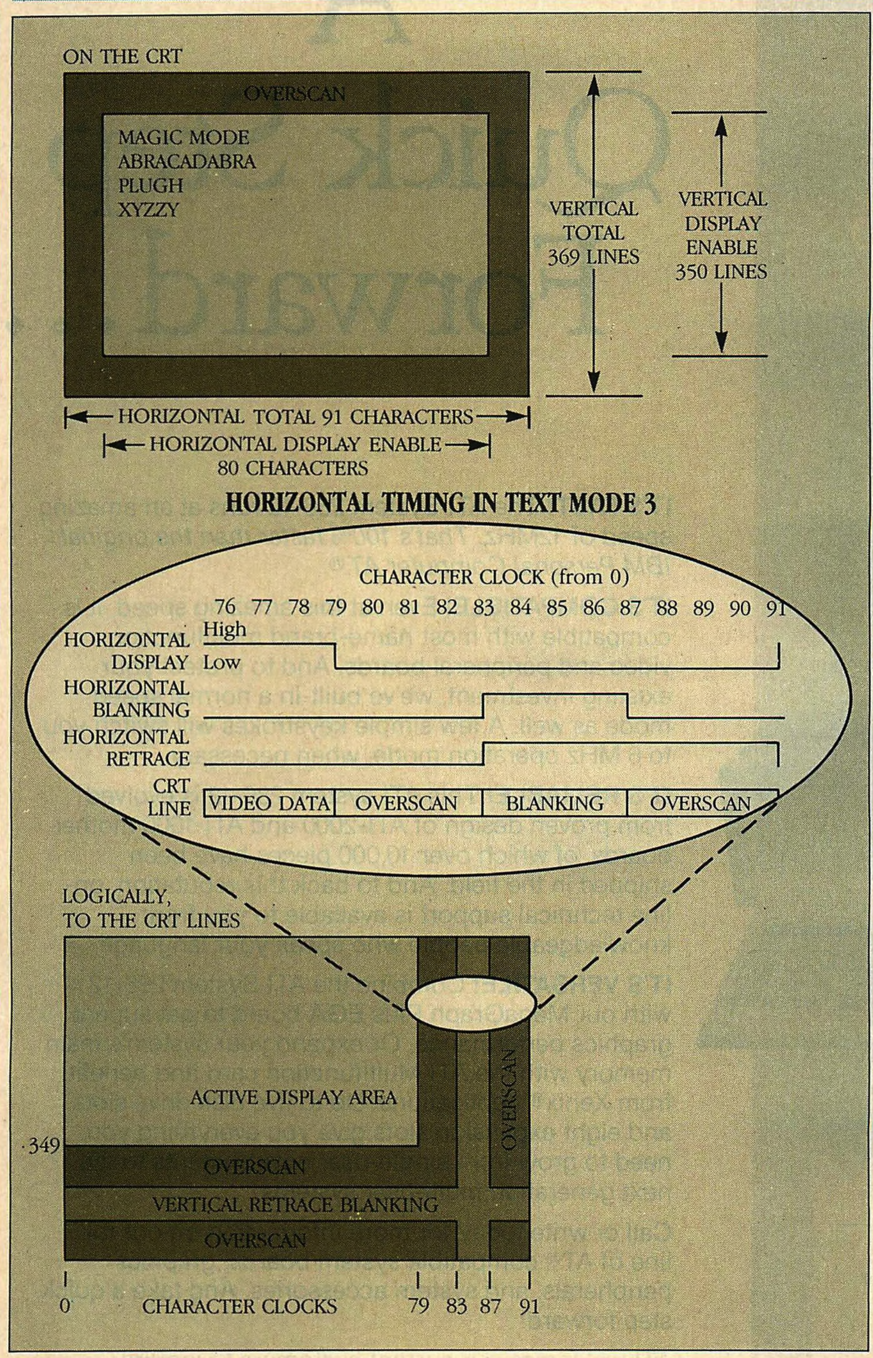
TABLE 1: *CRTC Registers for Text Mode 3*

INDEX	DECIMAL	HEX
00H Horizontal total	91	5BH
01H Horizontal display end	79	4FH
02H Start horizontal blanking	83	53H
03H End horizontal blanking	87	57H
04H Start horizontal retrace	81	51H
05H End horizontal retrace	91	5BH
06H Vertical total	364	16CH
09H Maximum scan line	13	0DH
12H Vertical display end	349	15DH
15H Start vertical blank	350	15EH
16H End vertical blank	362	10AH
10H Start vertical retrace	350	15EH
11H End vertical retrace	11	0BH

The data register in all cases is 3x4. All horizontal figures are given in character clocks, whereas all vertical figures are given in scan lines except for end vertical retrace, which synchronizes the vertical to the horizontal timings by specifying that the vertical retrace period ends 11 character clocks after it begins.

The fundamental vertical unit of an EGA raster is one horizontal scan line. As seen in figure 2, the CRTC defines the width of one complete horizontal line in terms of these character clocks. The actual number of character clocks selected to comprise one horizontal display line depends on the type of monitor used, coupled with the frequency of the dot clock. An enhanced monitor senses the polarity of the vertical retrace signal and alters its horizontal sync frequency accordingly; if the retrace pulse is negative-going, the monitor responds with a 21-KHz horizontal frequency and if the pulse is positive-going, the monitor switches to a frequency of 15.75-KHz. Newer moni-

FIGURE 2: *EGA Retrace Timing*



Although the computer screen appears as a rectangular active display area surrounded by an overscan boundary, the EGA logic counts the beginning of each frame at the upper left corner of the active display area. In character clocks, each horizontal line runs from 0 through 91, even though the electron beam jumps to the next physical scan line on or shortly after character clock 83.

tors, such as the NEC MultiSync and Sony MultiScan, can adjust to a broad range of input horizontal and vertical sync frequencies, including all of those possible with the EGA.

Logically, a horizontal line breaks down into the following three parts: active display enable when the CRTC directs the monitor dot guns to paint information on the screen; overscan between the line's active display periods when the guns are enabled but no information is painted; and blanking when the CRTC shuts off the guns entirely. Blanking occurs in the middle of overscan. During the horizontal blanking interval, the CRTC moves the video beam to the next line down on the screen. The overscan picks up after the blanking interval finishes, with the beam on the next horizontal line. The CRTC, however, does not increment its line count until it picks up again at the beginning of the active display area (in figure 2, this is the left-hand margin of the lower diagram.)

Table 1 lists the values for the pertinent EGA CRTC registers for mode 3 (80-by-25 text, 8-by-8 character block) on an enhanced monitor. (The notation used in this article is <Data Register>.<Index Register Value>). The horizontal total (I/O address 3x5.00) specifies a total line width of 91 character clocks. The display enable value (3x5.01) indicates that the active display stops after character 79, counting from 0. Between character 79 and start blanking (3x5.02), in this case 83, the CRTC sends out overscan to the monitor.

When blanking occurs, from character time 83 to 87 (end blanking 3x5.03), the adapter sends no information to the CRT and the video beam is off. If no blanking occurs, the screen is obscured by the beam painting pixels during retrace. Note that the actual value programmed into the end blanking register specifies only the five least significant bits for end blanking; the rest of the bits have other uses, which will be discussed shortly. After character 87, overscan restarts (now the video gun is on the next line) before the text pixels begin and continues until character 91 at which point the CRTC starts displaying text for the next line.

Start retrace (3x5.04) indicates that the signal to retrace the video beam back to the left edge of the screen should be raised at character 81, before blanking begins. However, a skew is specified by bits 5 and 6 of end retrace (3x5.05), here amounting to two clock times, so that the retrace pulse actually goes to the CRT when blanking starts at character 83. (The skew is used to align the retrace timings with other internal timings in the CRTC chip.) Looking at the screen with overscan active illustrates this. A very short overscan border is on the right-hand side of the screen, less than one character box in width. In this example, the retrace signal remains high for the duration of the scan: to character 91 (least significant bits 4 through 0 of end retrace, 3x5.05).

Most modes on the CRT have more than 256 scan lines, which means that some of the eight-bit wide vertical registers require an extra bit. The CRTC overflow register (3x5.07) contains these extra bits for several CRTC registers. The overflow yields nine bits for some of the vertical registers providing a total of 512 scan lines for the maxi-

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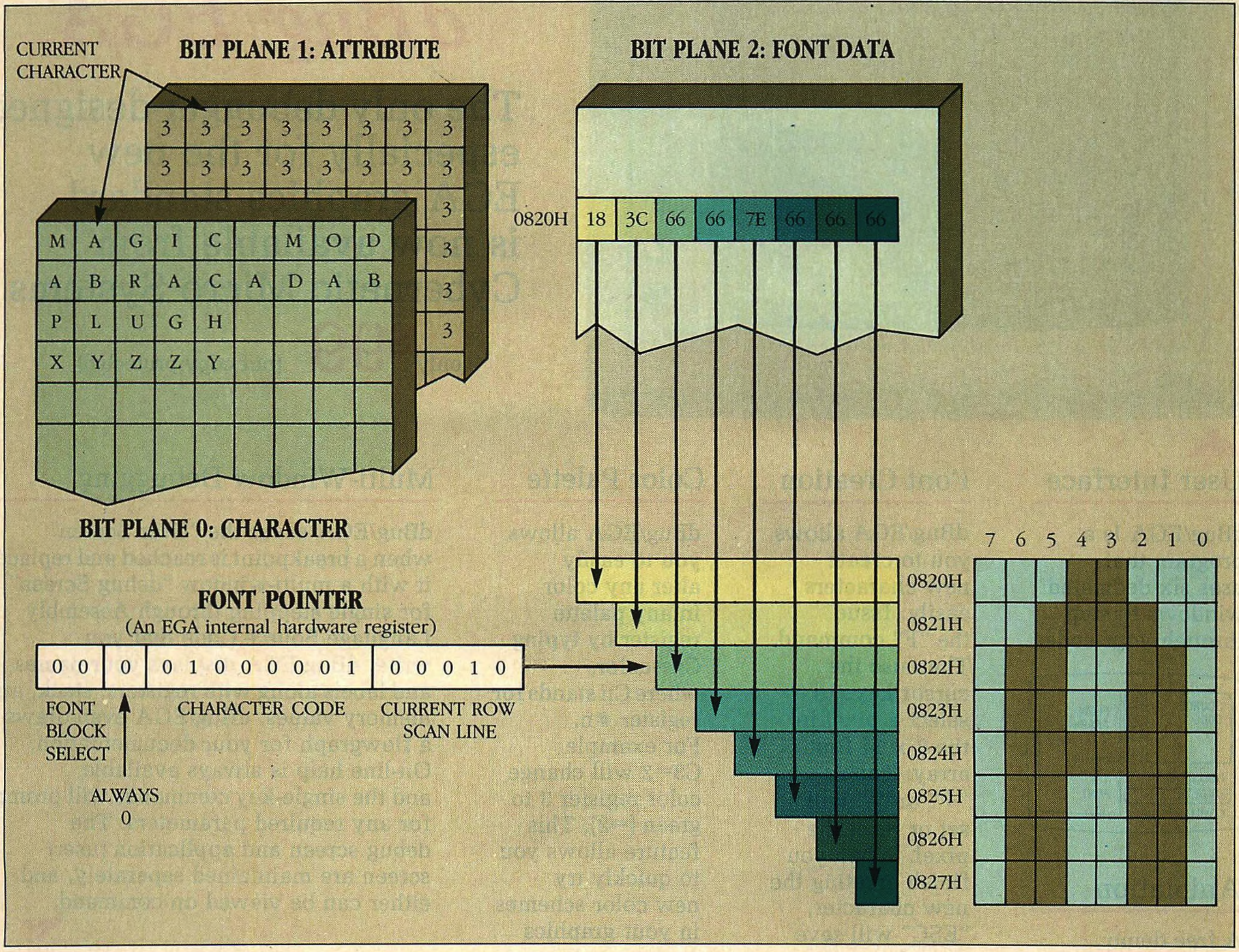
FIGURE 3: *Text Mode Font Storage*



Font data in text mode 3 is held in bit plane 2. The hardware assembles a font pointer for each displayed character from the character code, a font selection code, and the number of the current row scan line.

mum vertical dimension that the EGA can drive. In most monitors, the maximum is less than 512 due to limitations of the vertical sync frequency.

With each horizontal scan line displayed, two line counters are incremented: one for the total number of horizontal lines painted on the CRT and the other for the number of lines painted for the current character row. After painting the number of character spaces making up a row (defined in maximum scan line, 3x5.09), the CRTC updates its current buffer address to point to the next character row by adding to it the contents of the offset register (3x5.13).

After painting the desired number of horizontal scan lines down the computer screen (vertical display enable end 3x5.12 with overflow bit 1), the CRTC then enters the vertical overscan interval while the CRT's video gun is situated at the bottom of the screen. Just like horizontal retrace, the CRTC signals vertical retrace active (vertical retrace start 3x5.10 with overflow bit 2 and vertical retrace end 3x5.11) halfway through the overscan during the vertical blanking interval.

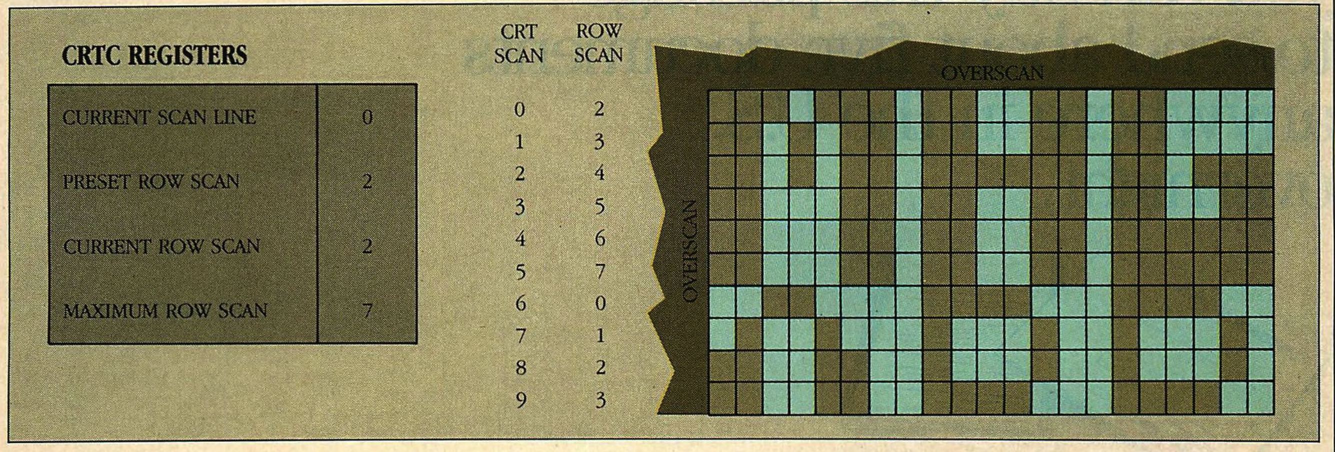
The start vertical blanking (3x5.15 with overflow bit 3) and end vertical blanking (3x5.16) registers define the start and duration of vertical blanking. By the end of vertical blanking, the video beam has moved to the top of the screen, and the CRTC returns to painting vertical overscan. The CRTC continues in overscan until vertical total (3x5.06 with overflow bit 0). At vertical total, the CRTC resets its internal counters to 0 and paints a new frame from the display buffer at the starting address (3x5.0C and 3x5.0D taken together for a 16-bit address). From the CRTC's perspective, the entire vertical blanking interval appears to be at the bottom of the CRT (see figure 2).

The CGA's vertical retrace bit reports only the vertical retrace signal, not the overscan status; it is true only after the CGA commands vertical retrace. Therefore, half of the CGA's overscan is finished before a program can sense that overscan is under way, leaving only half the time to manipulate registers and video RAM. Because in the EGA the vertical interrupt occurs at the vertical display enable end signal, the entire vertical overscan interval can be used to perform any changes to the fonts or reprogramming of the EGA registers (such as altering the palette RAM) that might cause interference during the active display period.

SMOOTH SCROLLING

Figures 3 and 4 show how vertical pixel scrolling works in text mode. After a vertical retrace, the CRTC sets its current character pointer to the buffer start address. It fetches the character and its

FIGURE 4: *Soft Scrolling in Text Mode*



The preset row scan register specifies the starting scan line at which the top character row is to be displayed. Incrementing this value one pixel at a time has the effect of scrolling the screen by a single scan line rather than an entire character row.

attribute to be displayed from video RAM and uses the character code and additional information (the active font and the current row scan) as an index into the font table. The EGA then shifts out the bits in the font byte to the CRT, toggling between the foreground and the background palette selections as specified in the attribute byte.

Normally, preset row scan (3x5.08) is 0, so that at the start of a new frame the CRTC fetches the font data for that character row starting with pixel byte 0 in the font table. To implement smooth vertical scrolling, the preset row scan specifies an initial row scan index for the first character row. Changing preset row scan achieves the smooth scrolling effect by starting a character row at pixel 2 (as in figure 4). The programmer can generate the illusion of smooth scrolling by updating this register during a vertical retrace, one or more scan lines at a time, and updating the buffer start address only when the entire row has been scrolled off the top of the screen. Preset row scan counts only into the first scan line. After the scan-line counter for the first character row equals the maximum scan line, the CRTC moves the current row address and begins painting scan line 0 of the next character row.

Performing smooth scrolling synchronized to vertical retrace periods should make it CPU-speed-independent. An interesting complication arose when developing the smooth scrolling test code in EGATEST (listing 1), a Modula-2 program written especially for this series to test EGA compatibles. Originally, routine WaitForVerticalRetrace (in module LOWEGA, listing 2a) simply waited for the vertical retrace pulse and returned to the calling logic to report that it had occurred.

The calling code then performed the smooth scrolling adjustment to preset row scan and immediately called WaitForVerticalRetrace again to wait for the next retrace pulse. On a PC this worked correctly, but on a 12-MHz AT compatible, the CPU was sufficiently fast to adjust preset row scan and to call WaitForVerticalRetrace again before the original retrace pulse had completed. The 12-MHz 80286 was fast enough, in fact, to perform smooth scrolling on several rows during one retrace pulse. The solution was to devise a second routine, WaitForVerticalDisplay, that waited for vertical retrace to end and active display to begin again.

As noted above, the EGA's timing sequencer arbitrates video RAM access between the ATC and the CPU, always in favor of the ATC. The timing sequencer also regulates how and which of the four bit planes are mapped into the CPU address space; however, it relegates actual CPU page address assignment to the graphics controller and hardware on the board.

The sequencer also specifies ninth dot-duplication mode for the bar graph and box draw characters (codes 192-223), which need to be contiguous in a horizontal dimension. An EGA font may be only eight pixels wide, so when the EGA drives a monochrome display with a 9-by-14 character box (mode 7), a line or box drawn with the graphics characters has one single-pixel break for each character block in every horizontal run. Duplicating font column 8 into font column 9 for these characters solves this problem. This feature can be turned off with a command to the ATC.

For every tick of the character clock, the adapter retrieves one byte in parallel from each of the four bit planes. In text modes, the two bytes from planes 2 and 3 are discarded, because two planes suffice to contain text and attributes. A second fetch to the video RAM retrieves the font information after the location is calculated (see figure 3). The graphics and attribute controllers share the responsibilities for formatting the 16 bits from planes 0 and 1 and the font information into video data to be shifted out to the CRT. The ATC is responsible for controlling horizontal pixel panning, soft font selection, and palette colors.

A SECOND EGA

IBM implies in the EGA technical reference that for applications requiring dual screens, two EGAs can be installed into a system, with the I/O addresses of one board rejumpered to 2xx instead of 3xx. Most EGA-compatible boards provide a jumper to remap the I/O addresses, but only one of the 19 compatible boards tested for this series (Tecmar's EGA Master) could disable the ROM when the I/O addresses were changed. Adding a second EGA board to the system results in two ROMs at the same memory address if the first ROM is not disabled. Popping out the ROM BIOS of one of the boards usually does not work. Perhaps two byte-for-byte identical ROMs could exist at the same address, but the chances are high for a timing error during CPU memory read. For those who would like to operate two EGAs in a single system, the lack of this jumper on most boards is a source of real irritation and a reflection of an incomplete design.

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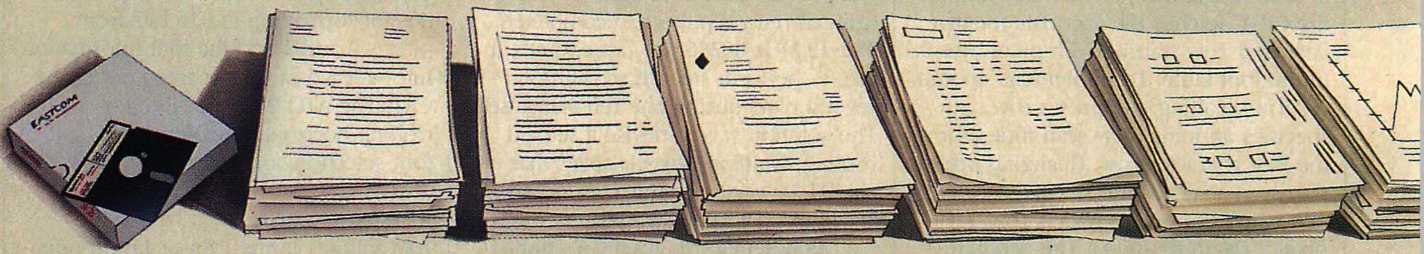

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Although the BIOS fixes the video RAM address assignments according to the particular display mode, the video RAM for a second EGA, which would not be accessed through the BIOS, could be placed in any other available video page. Both boards could then operate in high-resolution color mode simultaneously: one out of the normal high-resolution page and the other out of the CGA or monochrome page. In fact, a total of three display adapters can be placed into one system: two EGAs plus either a CGA or a monochrome adapter. IBM offers little guidance, however, on how to program for two coresident EGAs correctly.

The EGA provides hardware assistance in manipulating display memory. This assistance is essential in graphics mode because the EGA's display memory is large and organized into four planes. Accessing the display memory map without these aids would be very cumbersome for the CPU alone, which would have to instruct the EGA to map each of the four parallel bit planes into the CPU accessible address space; the CPU then would set or reset the bit within the byte according to the palette desired. This overhead would be too slow on 8088 PC implementations. The EGA's hardware assistance includes:

- the ability to move four bytes simultaneously from one area of display memory to another (write mode 1), which is essential for scrolling;
- several features that support area filling and rapid color flooding (write mode 2, color compare, set/reset);
- rotation of CPU data before writing to display RAM, useful for handling bit-mapped proportional fonts;
- masking off of selected bits on CPU writes, helpful in pixel manipulation and again in bit-mapped fonts;
- the ability to apply three logical functions (AND, OR, and XOR) to the data to be written and the contents of display memory, which speeds up many types of drawing;
- the ability to look quickly at eight pixels and to match them for color (color comparison).

The net effect of these features gives the EGA, when properly programmed, performance equal to the CGA, despite the EGA's far greater complexity, higher resolution, and greater number of colors.

DUPLICATING DIFFICULTIES

When designing a compatible EGA board, the manufacturer must confront three levels of difficulty: the chip, board, and BIOS levels. Incorporating all of IBM's functions into a chip set no longer poses a problem because the chips are readily available from Chips and Technologies. (C&T used reverse engineering to design an EGA-compatible chip set.) Many manufacturers have used the C&T set in their EGA boards. A few have created their own chip sets to obtain closer downward compatibility with the CGA and the monochrome adapter than either IBM's EGA or the C&T chip set is capable of providing. The issues surrounding the use of chip sets other than C&T will be discussed, along with the boards built around them, next month.

At the board level, "glue" to support the EGA custom chips must be provided: I/O address decoding and remapping, video RAM and addressing logic, interrupt processing, status buffers, board configuration, and ROM BIOS. For full compatibility the boards must include the EGA feature connector No products incorporate it yet.

Incorporating all of IBM's functions into a chip set no longer poses a problem because compatible chips are readily available from Chips and Technologies.

IBM graciously provided logic diagrams in its EGA technical reference, which aided the purely electrical design, but signal timings were another matter. For example, some of the first boards using the C&T chip set contain a timing problem that occurs under stressful circumstances. One such instance is when both the timing sequencer and the CRTC are being reprogrammed nearly simultaneously—for example, when changing the active font in the sequencer while the CRTC pans or brings up a split screen. (The test program called FantasyLand, described below, does this.) In this case, the entire screen is reduced to a jumble during the pan. This timing problem can be corrected simply by adding a small capacitor to the board.

Details matter here. The EGA board can respond to word output instructions to I/O registers (OUT DX,AX), as well as to byte outputs (OUT DX,AL). Microsoft Windows and EGATEST both take advantage of this feature in order to improve performance. Although undocumented, the IBM EGA ATC responds at 3C1H as well as at 3C0H, allowing it to be programmed with a single word OUT I/O instruction. This means that all EGA boards should share this characteristic. In other words, before building their own boards, the EGA compatible manufacturers had to understand the IBM EGA's eccentricities at a very low level—despite the lack of good documentation.

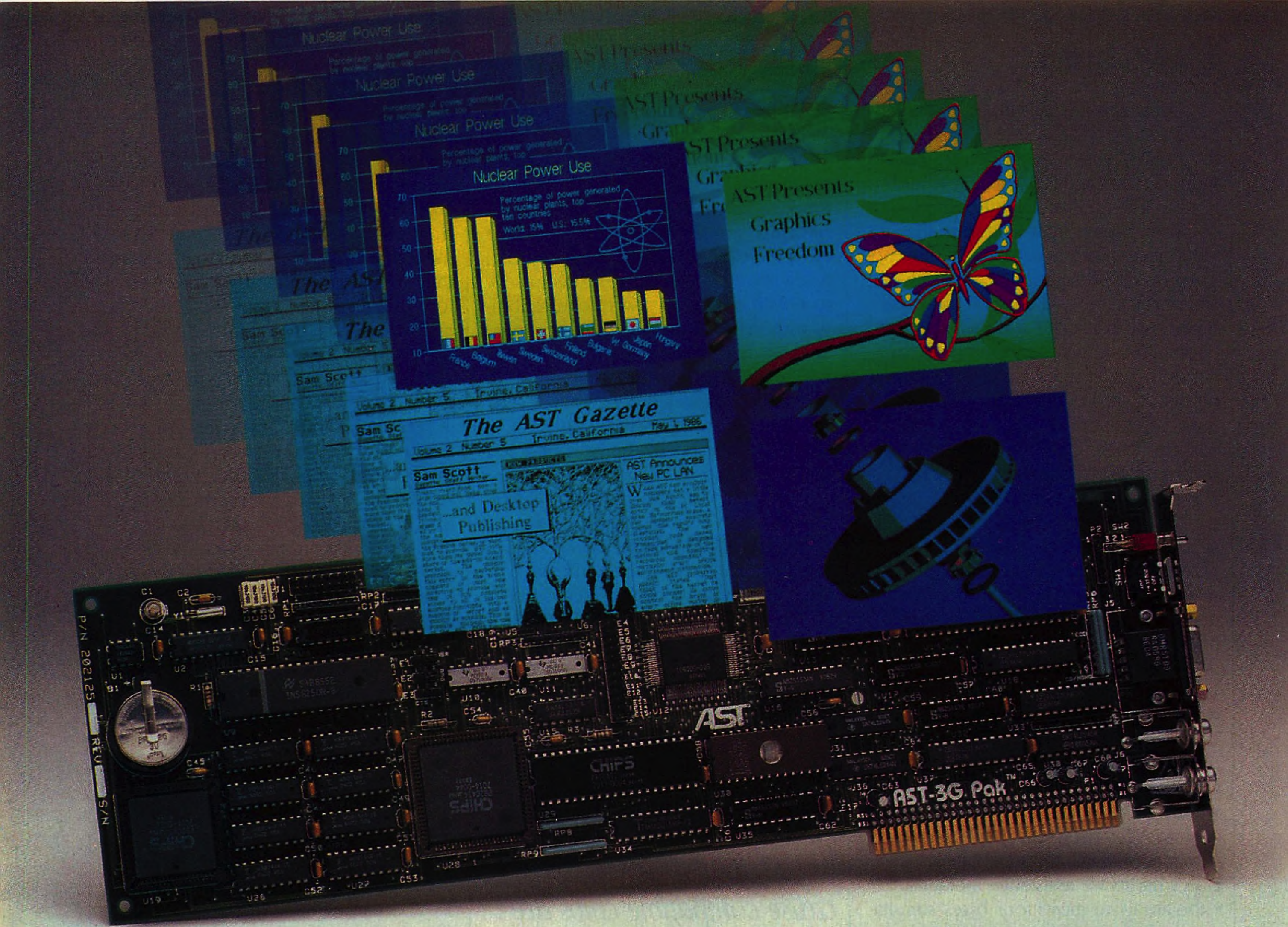
Compatibility dictates that some of the known IBM EGA hardware bugs be incorporated into any new chip set. Software containing work-arounds for IBM EGA bugs might work peculiarly or not at all on boards in which those bugs have been fixed. One bug that could have been eliminated without ill effect can be seen when pulling up a split screen in high-resolution graphics modes: the IBM board duplicates the first scan line of the split screen into the second scan line. The C&T chip set has this same "feature." The EGATEST program contains a screen that demonstrates this particular bug.

An error in IBM's EGA technical reference manual led some board manufacturers to misinterpret the meaning of the vertical retrace interrupt. Video 7's VEGA and Quadram's QuadEGA Plus, for example, placed the wrong polarity on this bit by following the technical reference rather than emulating the actual behavior of the EGA. Moreover, because of the way the bit interacts with IRQ2 (and because of the way IRQ2 may or may not interact with other interrupt-driven devices in the system), the bit is of little use in obtaining the vertical retrace interrupt status. (For further details on the EGA's vertical interrupt status bit, see the sidebar to "Software Sprites," Michael Abrash and Dan Illowsky, August 1986, p.130.)

BIOS COMPATIBILITY

Perhaps the worst problems of compatibility arise in the creation of a BIOS. The EGA BIOS is more complex and longer than that found in the original PC. It must provide CGA emulation in a different hardware environment. The hardware itself is an order of magnitude more complex than previous display cards, and all of the known BIOS graphics functions have to be supported, including CGA cursor emulation, which is a conceptually obscure and nearly uncommented section of the EGA BIOS source listing.

IBM's listing of its BIOS can be neither copied nor licensed. In fact, it



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contains traps for the unwary code copier—such as a do-nothing code fragment in the CGA palette emulation section, which IBM could cite as evidence of blatant copying, because it contributes nothing to EGA functions. Even more curious is the way the EGA BIOS programs the five-bit-wide CRTC end vertical blanking register (3x5.16) with a binary value encoded as eight bits—three more than are needed.

The new BIOS calls that are specific to the EGA are listed below:

- the palette-setting BIOS call (AH = 10H, subfunctions AL = 0, 1, 2, and 3) sets the palette and/or the overscan or enables blinking;
- the character generator (AH = 11H) subfunctions load font memory (subfunction 0xH), load fonts and reset the controller (subfunction 1xH), set font table pointers (2xH), or provide information to the caller (3xH);
- the alternate select function (AH = 12H) returns EGA information or sets up the new print screen routine;
- the write character string function (AH = 13H), found in the AT BIOS but not the PC or XT, writes an entire string of characters to the screen with a single BIOS call, rather than a single character at a time.

The BIOS has to extend the meaning of some of the function calls to incorporate the new graphics modes. The write and read character functions have to paint the characters in color into video RAM. The CRT mode-changing BIOS calls have to know the type of monitor attached to the EGA before reprogramming the adapter.

The EGA BIOS also passes on unrecognized video calls to INT 42H, where it revectors the motherboard ROM BIOS VIDEO code originally vectored at 10H. The BIOS in several of the tested boards lacks this pass-along code and simply returns on unrecognized functions—a silent bug that causes a program to ignore what seems to be a perfectly valid request for video services, because that particular BIOS does not support them.

IBM's EGA BIOS comes complete with bugs, leaving the EGA compatibles manufacturers in a quandary. Do the boards need to replicate the flaws, or should the standard be implemented correctly? Among the IBM BIOS bugs is one in the character generator routine, which incorrectly specifies the underline scan line location to the hardware when loading a new font. IBM's save area routines save the palette register contents correctly, and the overscan palette is included in the save area, but depending on which routines are called, the value saved for this register may be in one of two different offsets: 16 or 17. The CGA cursor emulation routines also do not work properly in all cases, leaving the user the job of programming the cursor shape.

The programmer can correct another BIOS bug of considerable importance. The IBM BIOS incorrectly interprets the warm boot flag in the PC. At warm boot the board enters the power-on self test, including a RAM test of the video memory. (The XT and AT do not suffer from this problem.) Some of the EGA compatible manufacturers either did not catch this bug or chose to implement warm reboot exactly the same way that IBM did.

TESTING THE COMPATIBLES

The IBM EGA and 19 compatible boards reviewed in this series were tested on a standard 640KB IBM PC, running under DOS 3.0, with the board being tested installed as the primary video adapter and the IBM monochrome adapter as a secondary board. The testing process followed two parallel tracks: all boards were run with a variety of commercially available software that claims to exercise some EGA function, and the boards faced a pair of aggressive custom software tests, FantasyLand and EGATEST, that were written to bypass the BIOS in certain circumstances and directly manipulate EGA RAM and I/O registers. Even with both FantasyLand and EGATEST, certain hardware features could not be tested.

IBM's EGA BIOS comes complete with bugs, leaving EGA compatible manufacturers in a quandary. Should the boards replicate or correct the flaws?

All the new boards come standard with 256KB of video RAM. IBM's EGA supports modes using 64KB, with fewer colors, by chaining four 16KB pages together into two 32KB planes. Future EGA compatibles are unlikely to have less than 256KB of RAM, so the 64KB functions were not tested.

The most famous DOS application, in a sense, is DOS itself. Getting DOS to operate correctly under an enhanced graphics board is the first big hurdle for the EGA BIOS. No board manufacturer would dare release a product if it fails any test at this level. BIOS routines must provide font loading, which must occur before DOS displays its prompt.

After verifying DOS operation under the EGA BIOS, the next test of BIOS compatibility involves switching between coresident monochrome and enhanced color displays under DOS control. STSC's Statgraphics tested simultaneous dual display modes.

Microsoft's Windows and Word are perhaps the most ambitious commercial users of the EGA to date. Windows performs some very nonstandard tasks—such as word OUTs to EGA I/O registers—and it brings the EGA up in color graphics mode 6 in order to paint its logo. The Write program under Windows proportionally spaces its fonts. Microsoft Word version 3.0, operating in 43-by-80 mode, provides a good test of font memory and alternate character row size capabilities.

The Halo and Dr. Halo graphics programs from Media Cybernetics fill closed polygons using the color comparison features of the graphics controller. These features were not addressed by EGATEST for space reasons but are a way of instructing the graphics controllers to look for specific colors in video RAM. When set up for color comparison, the graphics controllers read video RAM and return 1- or 0-bits for each pixel read, indicating whether or not those pixels are the requested color. In this way, pixels can be tested as quickly as video RAM can be read, rather than requiring the use of logical operators and CPU programming.

STSC's APL reprograms the fonts to include the APL character set. Graphics Software System's Computer Graphics Interface also runs bit-mapped fonts, providing another test of the data rotation and bit-plane masking functions of the EGA. Lotus 1-2-3 was included as one of the most popular business applications. All boards successfully ran every EGA-specific application program in the test sequence. So far, fears of EGA-compatible boards being incapable of running EGA-specific commercial applications are unfounded.

TORTURE TEST

These commercial software applications cannot provide a complete evaluation of an enhanced graphics board. Enter FantasyLand, which is nothing short of a torture test for EGAs. If a board correctly executes all of FantasyLand from

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beginning to end, that board has proven itself to be extraordinarily compatible with the IBM EGA. IBM wrote FantasyLand in 1984 in order to demonstrate some of the more obscure features of the EGA. The program was distributed very selectively to dealers and sales representatives; it has never been a product intended for sale.

FantasyLand builds a large, 150-by-400-character virtual text screen in the EGA video RAM. The screen uses custom fonts to create a map of an imaginary continent, complete with rivers, lakes, mountains, and fantastic creatures like dragons and sea serpents. The illusion of bit-mapped graphics is great, but all the drawings actually are done with custom characters from a 25-by-80 window into the larger virtual text screen. The program allows vertical and horizontal smooth scrolling throughout the map by using the cursor keys, allowing the user to tour FantasyLand. Help screens are implemented with the EGA's split-screen abilities and scroll smoothly up from the bottom of the screen when requested.

To make the test even more rigorous, FantasyLand uses the EGA's switchable fonts to create animation effects. The program loads several copies of a custom font into memory, and an interrupt service routine cycles through the copies every four system clock ticks. Certain characters in the custom font have slight differences across the copies so that, when cycled, they give the illusion of motion—a dragon flaps his wings, smoke billows from a chimney, grass waves in the wind. By tying the animation directly to the system's 8253 timer interrupt, font switching happens continuously, independent of CPU speed and divorced from other program operations. Rapid ongoing font changes, along with fast smooth scrolling in both directions, test subtle timing dependencies between subunits of the EGA. Early versions of several EGA-compatible boards failed FantasyLand, but once vendors' technicians understood what the program was doing, EGA board and BIOS updates allowed basic C&T EGA implementations to run all of FantasyLand without error.

CUSTOM TESTING

FantasyLand does not come with source code, so it is not completely clear which EGA BIOS calls and register manipulations it performs. The custom program, EGATEST, answers some of the questions that FantasyLand could not. EGATEST was written in Modula-2 under the Logitech Modula 2/86 system. All modules except the main program EGATEST.MOD (listing 1) have two listings each: a definition (.DEF) and an implementation module (.MOD). In both the .DEF and .MOD listings for the modules LOWEGA (listings 2 and 2a), DRAWPOLY (3 and 3a), FONTBUMP (4 and 4a), DOTTIME (5 and 5a), PAUSES (6 and 6a), POINTLIB (7 and 7a), and OPCODES (8 and 8a) are found at the end of this article. Also included is the batch file EGAMAKE.BAT (listing 9). All listings, along with an executable version of EGATEST, are available for downloading from PCTECHline.

Although quite lengthy, the modules contain many tools that allow the user to understand the operation of the EGA and implement many of its unique features. The concepts behind the program include exercising poorly understood features of the EGA: interrupt-driven font cycling, alternate addressing pages, save area features, alternate print screen with different size fonts, graphics blinking, split-screen operation, horizontal and vertical smooth scrolling, palette manipulation, and different writing modes. EGATEST also includes a timing routine for testing the speed of dot plotting, via BIOS and DMA.

If a board correctly executes all of FantasyLand from beginning to end, that board has proven itself to be extraordinarily compatible with the IBM EGA.

The main testing routines are contained in the module EGATEST. The program is split into several tests: split screen, panning, and scrolling with simultaneous font changing (FillAndSplitTest); character graphics (Mode3GraphicsTest); raster graphics and dot timing (Mode10GraphicsTest); save area (SaveAreaTest); and alternate font loading, CRT redefinition, and alternate print screen (Check43x80Mode).

Most of the generally useful routines comprising EGATEST reside in module LOWEGA. Many of these routines will be helpful to those wishing to add a second EGA to their systems, while still using the BIOS to control the first EGA. Any routine with *BIOS* in its name is an interface to the EGA BIOS. The nonBIOS routines maintain a separate set of cursors for actively displayed pages and know the status of the split screen and horizontal and vertical pans at all times. The routines also map their own text modes into the high-resolution video page (A000H). The first five routines—called EGAOutWord, WaitForVerticalRetrace, WaitForVerticalDisplay, SetPageOffset, and SetActiveFonts—are written as reentrant procedures by disabling Logitech's runtime error-trapping code around them.

Horizontal panning (procedure HorizScroll) is perhaps the most visually impressive aspect of the EGA. In any mode—text or graphics—the screen can be shifted left or right in increments of one pixel (as opposed to the eight-pixel minimum of the CGA). This makes for very smooth horizontal scrolling, which can be used in tandem with the variable row offset capability of the EGA (procedure SetLogicalRowSize) to scroll around a virtual screen much wider than the display. In other words, the row offset feature defines a variable logical line length that allows the programmer to reconfigure display memory to support a virtual display area up to 512 columns wide. Horizontal panning along with the variable starting address feature allow smooth movement of the text displayed on the screen to reflect any portion of the virtual screen in the EGA's display map.

Smooth vertical scrolling (procedures VerticalScrollUp and VerticalScrollDown in LOWEGA) is a text-mode feature that provides the same smooth motion up and down a virtual screen that horizontal panning provides across. Previous adapters supported only jumpy, character-row-at-a-time scrolling, but the EGA supports scan-line-at-a-time scrolling. Together, the smooth scrolling, horizontal panning, row offset, and starting address features, along with the large display memory map of the EGA, make it possible to define large display structures (such as extra-wide spreadsheets) entirely in display memory and then move about them with both ease and visual elegance.

The split-screen feature (procedures RollSplitScreenUp, RollSplitScreenDown, and SplitScreenAt, also in LOWEGA) provides a hardware window, with vertical smooth scrolling capabilities, that is ideal for popping up information and menus from the bottom of the screen. The split screen lets the programmer specify that after a given scan line on the CRT, the board should switch its data source for painting scan lines to offset 0 of the display memory

map. Hence, two completely separate areas of display memory can be juxtaposed. The greatest advantage of the split screen is that, when disabled, the screen instantly returns to its original appearance without any modification to the display memory. Its disadvantages are that it can split the screen only horizontally and the second window can show display memory starting at display map offset 0 only.

The EGA provides extensive and flexible soft font support in LOWEGA procedures LoadBiosFont and LoadUserFont. Unlike more primitive adapters, the EGA has fonts that are fully redefinable at all times in text mode. The EGA can store up to four text-mode fonts and can display any two at a time. The attribute byte controls font selection. Graphics mode fonts are stored outside of the EGA's font RAM.

Further graphics support is found in DRAWPOLY (listing 3a), which contains procedures for line and box drawing (DrawLine and DrawBox).

The vertical interrupt feature generates an interrupt on IRQ2 during the overscan interval after each vertical frame is drawn (which occurs 50 to 60 times per second), making flicker-free screen updating easy for tasks such as icon-based interfaces and animation.

The EGA's palette RAM (procedures SetPalette and SetOverscan in LOWEGA) maps the 16 color attributes that are available at any one time into any of 64 colors. Although IBM's documentation does not emphasize this, remapping may be performed in any BIOS mode at any time. The border color also can be set to any of 64 colors. These features allow the user to customize display colors in a program.

Underlining is a far more flexible task with the EGA than it was with previous adapters. The scan line of the character box at which underlining occurs is redefinable, and underlining is even possible in color text modes, although the underlined character must have a foreground attribute of 1 and a background attribute of 0. This does not necessarily have to yield white characters on a black background, however; the color attributes 0 and 1 can be redefined in the RAM palette.

The EGA is the first of the standard adapters in the IBM market to support graphics-mode blinking (procedures TurnOnBlinking and TurnOffBlinking), although this feature, too, is largely undocumented. Graphics-mode blinking, along with RAM-palette remapping, has the potential to support full emulation of all text-mode attributes in bit-mapped graphics mode, a capability that could make possible some superb word processing software.

Graphics-mode blinking operates differently from text-mode blinking. In graphics mode, the hardware reinterprets video bit plane 3 as the blink bit. The EGA maps all colors to the upper eight palette registers using the first three video planes. The attribute controller blinks those pixels with a bit set in bit plane 3 by alternating the mapping of the other three bit planes (0, 1, and 2) between the lower and upper eight palette registers.

Another BIOS feature not heavily exercised by commercial software is the alternate print screen routine. IBM developed a new print screen interrupt service routine because the EGA can display 43 text lines in one of its modes; the old print screen routine stopped at 25 lines. IBM taught the new routine about the rows variable—the number of displayable rows on the CRT screen. The new routine should work with any unusual font for any size character cell and any number of displayed rows on the screen. EGATEST loads the alternate print screen function and executes it. As can be expected, some BIOS routines of the EGA compatibles failed to execute properly here.

Given the current explosive growth in EGA sales, it is only a matter of time until the EGA is the minimum display standard for IBM desktop computing.

The routines in the module called FONTBUMP (listing 4a), SetUpFontBumping and ResetFontBumping, are designed specifically to confound the hardware on the EGA. This subprogram attaches itself to the system clock interrupt service routine. With every fourth tick of the 8253 clock, the interrupt changes the actively displayed font. This proved to be the most difficult test for any enhanced graphics board to pass; IBM itself failed for no readily identifiable reason. Although all of the basic C&T implementations passed this test without difficulty, several of the more advanced boards reviewed in next month's issue were unable to handle it.

Module DOTTIME (listing 5a) times 65,000 iterations of a pixel plot operation three ways: through the BIOS, through a Modula-2 subprogram call (with arguments pushed onto the stack), and through direct in-line assembly code. The results for the in-line assembly routine and the subprogram call were the same across all EGA compatibles: 17.9 and 20.6 seconds, respectively, reflecting the close electrical similarity of boards incorporating the C&T chip set. These numbers will *not* be shared by the non-C&T boards to be reviewed next month in which the BIOS calls varied widely from a reasonable 27.4 seconds to an agonizing 64.3 seconds. While the hardware is nearly the same, the software sold with EGA-compatible boards varies radically, as these timings indicate.

EGATEST is not meant to be used on monitors other than the Enhanced Graphics Display or mode-sensing monitors, such as NEC's MultiSync. The testing program will run only on EGA compatibles with a full complement of 256KB of video RAM. Any amount short of that will abort with an "insufficient memory" error message.

Critically speaking, the EGA's awkward architecture makes it quite slow. Manipulating the EGA's multiplane bit map takes a lot of time. Coupling that with a BIOS interface mandating a context switch—that is, pushing all registers on the stack—means that BIOS calls to paint pixels on the CRT will probably move like molasses.

Most current software does not take advantage of the EGA's advanced features largely because most current software has been ported from implementations for the CGA or Hercules Graphics Card. Moreover, any software that uses the EGA's extended features is locked into operation on the EGA alone, and most developers are not yet willing to forsake the installed base of CGAs and Hercules boards. Given the current explosive growth in EGA sales, however, it is only a matter of time until the EGA becomes the minimum display standard for IBM desktop computing. Then, 100-percent EGA compatibility, no matter how difficult to achieve, will pass from being desirable to being absolutely essential.

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LISTING 1: EGATEST.MOD

```
MODULE EGATest;
(*
Title   : EGATest.mod

    Enhanced Display Adapter Testing Program

LastEdit: July 22, 1986
Author  : John T. Cockerham, M.D.
System  : LOGITECH MODULA-2/86
*)
IMPORT Terminal;
IMPORT InOut;
FROM SYSTEM IMPORT ADDRESS, ADR;
FROM LowEGA IMPORT
  InitEGA, SetUpAlpha, SetUpHiRes, Write, WriteString,
  SetActivePage, TurnOnBlinking, TurnOffBlinking, MonitorType,
  HorScrollRight, HorizScroll, ResetHorizScroll, VerticalScrollDown,
  ResetVerticalScroll, SetCursorPoint, SetCursor, SetBiosPalette,
  WaitForVerticalRetrace, SplitScreenAt, RollSplitScreenUp,
  RollSplitScreenDown, SetPalette, SetOverscan, BiosCRTParams,
  MakeSecondGraphicsPage, DrawPoint, SetBiosCursorPoint,
  RowsOnScreen, BytesPerChar, EGABiosRec, BiosCRTVars, ActivePage,
  FillGraphicsPage, GetCursorPoint, LoadBiosFont, SetModeBios,
  GetAlternatePrintScreen,PrintScreen, FontType, SetActiveFonts,
  TotalVerticalScanLines, MaxVideoPages, EGABiosParams, EGASavePtr,
  MemoryInstalled, MemoryInstalled256K, WaitForVerticalDisplay;
FROM PointLib IMPORT Point, MakePoint, BumpPointY;
FROM FontBumper IMPORT SetUpFontBumping, ResetFontBumping;
FROM Conversions IMPORT ConvertCardinal;
FROM Strings IMPORT Insert;
FROM Pauses IMPORT Pause, GraphicsPause;
FROM DrawPoly IMPORT DrawLine, DrawBox;
FROM DotTime IMPORT DotTimingTest;

CONST Blank = 020H;   (* An ASCII Blank    *)
      VIDEO = 010H;   (* Bios video int    *)
      HiRes = 010H;   (* Color Hi Res Mode *)
      Alpha = 003H;   (* Color Alpha Mode  *)
      Page0 = 0;  Page1 = 1;
      WaitingTime = 500;


  PROCEDURE SayHello;
  BEGIN
    SetModeBios(Alpha); SetUpAlpha;
    SetActivePage(Page1);
    Pause('PC TECH JOURNAL EGA Testing Program');
    Pause('by John T. Cockerham');
    Pause('Portions copyright (c) Logitech Corporation, 1986');
    Pause('Copyright (c) PC Tech Journal, 1986');
    Pause('Aborting this program during Font Bumping...');
    Pause('Will leave the EGA in an undefined state.');
  END SayHello;
PROCEDURE CheckMemorySize() : BOOLEAN;
BEGIN
  RETURN (MemoryInstalled = MemoryInstalled256K);
END CheckMemorySize;

PROCEDURE WaitAWhile;
  VAR i : CARDINAL;
BEGIN
  FOR i := 0 TO WaitingTime DO
    WaitForVerticalRetrace;
    WaitForVerticalDisplay;
  END;
END WaitAWhile;

  (* This routine makes a split screen in alpha mode *)
PROCEDURE MakeSplitScreen(NumberOfRows,NewPage,NewLine : CARDINAL);
  VAR
    Cursor : Point; Lines : CARDINAL;
BEGIN
  Lines := NumberOfRows * BytesPerChar;
  SetActivePage(NewPage);    MakePoint(Cursor, 0, NewLine);
  SetCursorPoint(ActivePage, Cursor);
  RollSplitScreenUp(Lines);
END MakeSplitScreen;

PROCEDURE SplitAndScroll2Ways;
  VAR i : CARDINAL;
BEGIN
  Pause('Splitting and Scrolling 3 ways at a time');
  FOR i := 0 TO 300 DO
        (* Here scroll horizontally by one *)
    HorScrollRight;
        (* Here bring up one line on the split screen *)
    SplitScreenAt(TotalVerticalScanLines - i);
        (* Here scroll vertically by one line *)
    VerticalScrollDown;
  END;
  WaitAWhile;
END SplitAndScroll2Ways;

PROCEDURE FillPage(PageNumber : CARDINAL);
  VAR
     j : INTEGER; CursorStart : Point;
BEGIN
  SetActivePage(PageNumber);   MakePoint(CursorStart, 0, 0);
  SetCursorPoint(PageNumber, CursorStart);
  FOR j := 0 TO (ORD(RowsOnScreen) + 1) * BiosCRTParams.CRTCols - 1
    DO Write (PageNumber, CHR(ORD('0') + PageNumber), 3);
  END;
END FillPage;

PROCEDURE FillAndSplitTest;
PROCEDURE SoftScrollTest(Page, Lines  : CARDINAL);
  VAR l : CARDINAL;   p : Point;
BEGIN
  SetActivePage(Page);
  MakePoint(p, 10, 10); SetCursorPoint(ActivePage, p);
  Pause('Vertical scrolling test');
  l := 0;
  WHILE l < Lines DO VerticalScrollDown; INC(l);  END;
  ResetVerticalScroll;
  Pause('End vertical scrolling test');
END SoftScrollTest;

PROCEDURE SplitCursorTest;
  VAR p : Point;
BEGIN
  Pause('Split cursor test');    SetActivePage(ActivePage);
  ResetHorizScroll;              MakePoint (p, 0, 3);
  SetCursorPoint(ActivePage, p); HorizScroll(4);
  WaitAWhile;
  ResetHorizScroll;
  Pause('End split cursor test');
END SplitCursorTest;

PROCEDURE WriteCP(line : CARDINAL);
  VAR s : ARRAY [0..15] OF CHAR;
      p : Point; i, color : CARDINAL;
BEGIN
  FOR i := 0 TO HIGH(s) DO s[i] := CHR(Blank); END;
  MakePoint(p, 0, line);         color := line + 2;
  SetCursorPoint(ActivePage, p);
  WriteString(ActivePage, ' Line ', color);
  ConvertCardinal(line, 3, s);
  WriteString(ActivePage, s, color);
END WriteCP;

(* Variables for the main routine  *)
VAR   i : INTEGER;     p : Point;
BEGIN
  SetActivePage(Page1);
  Pause('Filling and Splitting Test');
     (* Here fill all of the video pages with something *)
  FOR i := 0 TO MaxVideoPages DO  FillPage(i);  END;
     (* Test the soft scrolling in several ways *)
  SoftScrollTest(4, 180);
  Pause('Horizontal Pixel Pan to Left');
  HorizScroll(280); Pause('Pixel pan to right');
  HorizScroll(-280);
     (* Fill up Page 0 with some other information *)
  SetActivePage(Page0);    FOR i := 0 TO 15 DO WriteCP(i); END;
     (* Turn on the overscan to green *)
  Pause('Turning on green border'); SetOverscan(2);
     (* Scroll up the split screen with 4 lines of text *)
  Pause('Bringing up Split Screen with 4 lines of text');
```

```
    MakeSplitScreen(4, 3, 14); WaitAWhile;
    Pause('Split Screen Test Complete');
        (* Now torture the board doing everything at once *)
    IF SetUpFontBumping(4) THEN
      Pause('Font Bumping enabled at 4.5 times per second');
    ELSE
      Pause('Unable to set up Font Bumping');
    END;
    SplitAndScroll2Ways;
        (* See what happens when the cursor split across 2 rows *)
    SplitCursorTest;      Pause('End of Fill and Split Test');
    ResetFontBumping;     Pause('Font bumping disabled');
  END FillAndSplitTest;

PROCEDURE CycleTheFontsTest;
  VAR i : CARDINAL; s, t : ARRAY [0..14] OF CHAR;

  PROCEDURE DisplayEntireFont;
    VAR p: Point;
  BEGIN
    SetActivePage(Page1);
    MakePoint(p, 0, 0);
    SetCursorPoint(ActivePage, p);
    FOR i := 0 TO 255 DO Write(Page1, CHR(i), 5); END;
  END DisplayEntireFont;

BEGIN
  SetActiveFonts(0, 0);
  DisplayEntireFont;
  Insert('This is Font ', s, 0);
  Pause('Cycling through the Active Fonts');
  FOR i := 0 TO 3 DO
    SetActiveFonts(i, i);      ConvertCardinal(i, 2, t);
    Insert(t, s, 13);          Pause(s);
  END;
END CycleTheFontsTest;

PROCEDURE Mode3GraphicsTest;
  (* This routine tests the line graphics characters on the CRT*)
  CONST
        LLBoxCorner1 = 192;          URBoxCorner1 = 191;
        LRBoxCorner1 = 217;          ULBoxCorner1 = 218;
        VertLine1    = 179;          HorizLine1   = 196;
        LLBoxCorner2 = 200;          URBoxCorner2 = 187;
        LRBoxCorner2 = 188;          ULBoxCorner2 = 201;
          VertLine2    = 186;          HorizLine2   = 205;
  VAR   i : CARDINAL;

  PROCEDURE WriteCharAt(ch : CHAR; Row, Column, Color : CARDINAL);
     VAR p: Point;
    BEGIN
    MakePoint(p, Column, Row); SetCursorPoint(ActivePage, p);
    Write(ActivePage, ch, Color);
  END WriteCharAt;

BEGIN
  Pause('Text 80 Graphics Test');
  SetActivePage(0);
  WriteCharAt(CHR(ULBoxCorner1), 0,  0, 3);
  FOR i := 1 TO 78 DO Write(ActivePage, CHR(HorizLine1), 3) END;
  WriteCharAt(CHR(URBoxCorner1), 0, 79, 3);
  WriteCharAt(CHR(LLBoxCorner1), 24, 0, 3);
  FOR i := 1 TO 78 DO Write(ActivePage, CHR(HorizLine1), 3) END;
  WriteCharAt(CHR(LRBoxCorner1), 24, 79, 3);
  FOR i := 1 TO 23 DO
    WriteCharAt(CHR(VertLine1), i,  0, 3);
    WriteCharAt(CHR(VertLine1), i, 79, 3);
  END;
  WriteCharAt(CHR(ULBoxCorner2), 2,  2, 3);
  FOR i := 3 TO 76 DO Write(ActivePage, CHR(HorizLine2), 3) END;
  WriteCharAt(CHR(URBoxCorner2), 2, 77, 3);
  WriteCharAt(CHR(LLBoxCorner2), 22, 2, 3);
  FOR i := 3 TO 76 DO Write(ActivePage, CHR(HorizLine2), 3) END;
  WriteCharAt(CHR(LRBoxCorner2), 22, 77, 3);
  FOR i := 3 TO 21 DO
    WriteCharAt(CHR(VertLine2), i,  2, 3);
    WriteCharAt(CHR(VertLine2), i, 77, 3);
  END;
  WriteCharAt(CHR(206), 17, 14, 3);
  Pause('End Monochrome character Graphics Test');
END Mode3GraphicsTest;
```

```
PROCEDURE Mode10GraphicsTest;
  VAR
      p1, p2 : Point;
BEGIN
  Pause('Raster Graphics Test Starting');
  DotTimingTest;
  SetModeBios(Alpha); SetUpAlpha; Pause('Line and Fill Test ');
  SetModeBios(HiRes); SetUpHiRes; SetActivePage(0);
  MakePoint(p1, 0, 0);        MakePoint(p2, 639, 349);
  DrawBox(p1, p2, 14);        MakePoint(p1, 1, 1);
  MakePoint(p2, 638, 348);    DrawBox(p1, p2, 5);
  MakePoint(p1, 5, 5);        MakePoint(p2, 600, 300);
  DrawBox(p1, p2, 6);
  GraphicsPause(Page0, 'Yellow Box Drawn at edge of screen');
  TurnOnBlinking;
  GraphicsPause(Page0, 'Blinking Test ongoing              ');
  TurnOffBlinking;
  GraphicsPause(Page0, 'Recoloring Palettes 0 and 8        ');
  SetPalette(8, 0);           SetPalette(2, 18);
  SetPalette(10, 36);         TurnOnBlinking;
  GraphicsPause(Page0, 'Second Blink Test.                 ');
  TurnOffBlinking;            MakeSecondGraphicsPage;
  FillGraphicsPage(10);       RollSplitScreenUp(110);
  GraphicsPause(Page1, 'Double Yellow Line on Split Screen');
  GraphicsPause(Page1, 'Turning Blinking On Again          ');
  TurnOnBlinking;        FillGraphicsPage(8);
  GraphicsPause(Page1, 'Ending Mode 10 Graphics Test       ');
  TurnOffBlinking;            RollSplitScreenDown;
END Mode10GraphicsTest;

PROCEDURE FillPageTerm(s : ARRAY OF CHAR);
  VAR i, NumberOfTimes : CARDINAL;
BEGIN
  NumberOfTimes := 43 * 80 DIV HIGH(s);
  FOR i := 1 TO NumberOfTimes DO
    Terminal.WriteString(s);  END;
END FillPageTerm;

PROCEDURE Check43x80Mode;
BEGIN
  SetModeBios(03H);
  LoadBiosFont(DoubleDotFont, TRUE, 0);
  GetAlternatePrintScreen;
  FillPageTerm(' PC Tech Journal EGA Test ');
  PrintScreen;
  SetUpAlpha; Pause('End 43 by 80 test');
END Check43x80Mode;

VAR NewSaveArea : RECORD
        VideoParamsPointer : ADDRESS;
        DynamicSavePointer : ADDRESS;
        AlphaAuxilaryPtr   : ADDRESS;
        GraphicsAuxilaryPtr: ADDRESS;
        Reserved5          : ADDRESS;
        Reserved6          : ADDRESS;
        Reserved7          : ADDRESS;
        Reserved8          : ADDRESS;
      END;
    DynamicSaveArea : ARRAY [0..256] OF CHAR;
    OldSaveAreaPtr  : ADDRESS;

(* This routine checks out the save area functions of the BIOS
   It firsts saves the old pointer, then it points to a new
   table. A mode set is called, and one palette is changed. The
   save area is then checked to make sure the change was passed
   back to the save area.  *)
PROCEDURE SaveAreaTest;
  PROCEDURE DumpSaveArea;

    PROCEDURE WritePal(index : CARDINAL; Pal : CHAR);
    BEGIN
        InOut.WriteString('Palette '); InOut.WriteCard(index, 3);
        InOut.WriteString('. ');       InOut.WriteHex(ORD(Pal), 2);
    END WritePal;

    VAR i : CARDINAL;
  BEGIN
    FOR i := 1 TO 3 DO InOut.WriteLn; END;
    FOR i:= 0 TO 15 BY 2 DO
      WritePal(i, DynamicSaveArea[i]);
```

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```
        InOut.WriteString('     ');
        WritePal(i+1, DynamicSaveArea[i+1]);
        InOut.WriteLn;
      END;
      InOut.WriteString('Overscan  ');
      InOut.WriteHex(ORD(DynamicSaveArea[16]),2);
      InOut.WriteLn;
    END DumpSaveArea;

  BEGIN
    SetModeBios(Alpha);  SetUpAlpha;  SetActivePage(Page1);
    Pause('Save Area Test');    SetModeBios(Alpha);
    OldSaveAreaPtr := EGASavePtr;
    NewSaveArea.VideoParamsPointer := EGASavePtr^;
    WITH NewSaveArea DO
      DynamicSavePointer := ADR(DynamicSaveArea);
      AlphaAuxilaryPtr   := 0H:0H;
      GraphicsAuxilaryPtr:= 0H:0H;
      Reserved5          := 0H:0H;
      Reserved6          := 0H:0H;
      Reserved7          := 0H:0H;
      Reserved8          := 0H:0H;
    END;
         (* Now set up the new pointer *)
    EGASavePtr := ADR(NewSaveArea.VideoParamsPointer);
         (* Issue a mode change call through the Bios *)
         (* Now dump the palette stuff out on the console *)
    SetModeBios(Alpha);
    DumpSaveArea;
         (* Change Palette 5 to something different *)
    SetBiosPalette(5, 031H);
    Terminal.WriteString('New Palette Value at 5');
    Terminal.WriteLn;
    DumpSaveArea;
    EGASavePtr := OldSaveAreaPtr; SetUpAlpha;
    Pause('Ending Save Area Test');
    SetModeBios(Alpha);    SetUpAlpha;
  END SaveAreaTest;

BEGIN
  IF InitEGA(Color) AND CheckMemorySize() THEN
    SayHello;
    FillAndSplitTest;
    CycleTheFontsTest;
    Mode3GraphicsTest;
    Mode10GraphicsTest;
    SaveAreaTest;
    Check43x80Mode;
    Pause('Finished');
    SetModeBios(Alpha);
  ELSE
    SetModeBios(Alpha);
    IF NOT CheckMemorySize() THEN
      InOut.WriteString('Insufficient Graphics Ram for Test.');
    ELSE
      InOut.WriteString('Unknown Error During Initialization.');
    END;
    InOut.WriteLn;
  END;
END EGATest.
```

LISTING 2: LOWEGA.DEF

```
DEFINITION MODULE LowEGA;

FROM SYSTEM IMPORT ADDRESS;
FROM PointLib IMPORT Point;

EXPORT QUALIFIED
  EGAOutWord, InitEGA, SetUpAlpha, SetUpHiRes, CursorOffset,
  BumpCursor, Write, WriteString, SetActivePage, SetPageOffset,
  TurnOnBlinking, TurnOffBlinking, HorScrollLeft, MonitorType,
  HorScrollRight, HorizScroll, ResetHorizScroll, VerticalScrollUp,
  VerticalScrollDown, ResetVerticalScroll, SetCursorPoint, SetCursor,
  WaitForVerticalRetrace, SplitScreenAt, RollSplitScreenUp,
  RollSplitScreenDown, ResetSplitScreen, SetPalette, SetOverscan,
  MakeSecondGraphicsPage, DrawPoint, EGABiosParams, BiosCRTParams,
  DisplayBuffer, RowsOnScreen, BytesPerChar, EGABiosRec, BiosCRTVars,
  ActivePageOffset, MaxPage, FeatureBits, SwitchSettings,
  MemoryInstalled, ActivePage, FillGraphicsPage, SwitchToColorBios,
  SwitchToMonoBios, ColorBiosMode, LoadBiosFont, FontType,
  GetAlternatePrintScreen, PrintScreen, SetActiveFonts, SetModeBios,
  LoadUserFont, ResetVideoPage, TotalVerticalScanLines, MaxVideoPages,
  WriteBiosString, WriteBios, SetBiosCursorPoint, GetCursorPoint,
  EGASavePtr, SetBiosPalette, MemoryInstalled64K, MemoryInstalled128K,
  MemoryInstalled192K, MemoryInstalled256K, WaitForVerticalDisplay;

CONST    MaxVideoPages = 7;
         MemoryInstalled64K  = 0;
         MemoryInstalled128K = 1;
         MemoryInstalled192K = 2;
         MemoryInstalled256K = 3;

TYPE
  MonitorType = (Monochrome, Color);
  FontType = (MonochromeFont, DoubleDotFont);
  (* Enhanced Graphics Adapter Bios Variables*)
  EGABiosRec =  RECORD
          Rows          : CHAR;
          Points        : CARDINAL;
          InfoAndInfo3  : BITSET; (*Info=low 8 bits Info 3=high*)
          SavePtr       : ADDRESS;  END;
  BiosCRTVars =  RECORD
          CRTMode       : CHAR;
          CRTCols, CRTLen: CARDINAL;
          CRTStart      : CARDINAL;
          CursorPosition : ARRAY [0 .. 7] OF CARDINAL;
          CursorMode    : CARDINAL;
          ActivePageNum : CHAR;
          ADDR6845      : CARDINAL;
          CRTCGA3X8     : CHAR;
          CRTCGA3X9     : CHAR;  END;

VAR
   ActivePageOffset, MaxPage, FeatureBits,
   SwitchSettings, MemoryInstalled, ActivePage,
   TotalVerticalScanLines : CARDINAL;
   (* BIOS RAM Parameters*)
   EGABiosParams [0:484H]    : EGABiosRec;
   BiosCRTParams [0:449H]    : BiosCRTVars;
   DisplayBuffer [0A000H:0H] : ARRAY [0..65500] OF CHAR;
   RowsOnScreen  [0:484H]    : CHAR;
   BytesPerChar  [0:485H]    : CARDINAL; (* Font character size *)
   EGASavePtr    [0:4A8H]    : POINTER TO ADDRESS;

PROCEDURE EGAOutWord(EGAPort, DeviceRegister, Value : CARDINAL);
PROCEDURE InitEGA(EGAMonitor: MonitorType) : BOOLEAN;
PROCEDURE SetUpAlpha;
PROCEDURE SetUpHiRes;
PROCEDURE SwitchToColorBios;
PROCEDURE SwitchToMonoBios;
PROCEDURE ColorBiosMode() : BOOLEAN;
PROCEDURE CursorOffset(Page : CARDINAL) : CARDINAL;
PROCEDURE BumpCursor(Page : CARDINAL);
PROCEDURE Write(Page : CARDINAL; ch : CHAR; color : INTEGER);
PROCEDURE WriteString(Page : CARDINAL; s : ARRAY OF CHAR;
                      c : CARDINAL);
PROCEDURE SetActivePage(page : CARDINAL);
PROCEDURE SetPageOffset(where : CARDINAL);
PROCEDURE TurnOnBlinking;
PROCEDURE TurnOffBlinking;
PROCEDURE HorScrollLeft;
PROCEDURE HorScrollRight;
PROCEDURE HorizScroll(pixels : INTEGER);
PROCEDURE ResetHorizScroll;
PROCEDURE VerticalScrollUp;
PROCEDURE VerticalScrollDown;
PROCEDURE ResetVerticalScroll;
PROCEDURE SetCursorPoint(Page : CARDINAL; p : Point);
PROCEDURE SetCursor(Page : CARDINAL);
PROCEDURE GetCursorPoint(VAR p : Point; Page : CARDINAL);
PROCEDURE WaitForVerticalRetrace;
PROCEDURE WaitForVerticalDisplay;
PROCEDURE SplitScreenAt(ScanLine : CARDINAL);
PROCEDURE RollSplitScreenUp(SplitSizeLines : CARDINAL);
PROCEDURE RollSplitScreenDown;
PROCEDURE ResetSplitScreen;
PROCEDURE SetPalette(Palette, Color : CARDINAL);
PROCEDURE SetBiosPalette(Palette, Color : CARDINAL);
PROCEDURE SetOverscan(Color : CARDINAL);
PROCEDURE MakeSecondGraphicsPage;
PROCEDURE FillGraphicsPage(Color : CARDINAL);
```

```
  PROCEDURE DrawPoint(p : Point; color : CARDINAL);
  PROCEDURE LoadBiosFont(Font : FontType; ResetFlag : BOOLEAN;
                         Block : CARDINAL);
  PROCEDURE GetAlternatePrintScreen;
  PROCEDURE PrintScreen;
  PROCEDURE SetActiveFonts(FontA, FontB : CARDINAL);
  PROCEDURE SetModeBios(Mode : CARDINAL);
  PROCEDURE LoadUserFont(VAR Font : ARRAY OF CHAR;
                             ResetFlag : BOOLEAN;
                             Block, Count, Points : CARDINAL);
  PROCEDURE ResetVideoPage;
  PROCEDURE WriteBios(Character : CHAR; Color : CARDINAL);
  PROCEDURE WriteBiosString(msg : ARRAY OF CHAR; Color : CARDINAL);
  PROCEDURE SetBiosCursorPoint(Page : CARDINAL; p : Point);
END LowEGA.
```

LISTING 2a: LOWEGA.MOD

```
IMPLEMENTATION MODULE LowEGA;
(*
Title   : LowEGA

          Low level EGA facilities
          Supplies useful workarounds to the Bios and
          extensions thereto such as split screen.
LastEdit: July 14, 1986
Author  : John T. Cockerham, M.D.
System  : LOGITECH MODULA-2/86
*)
                  (* This is a low level module*)
  FROM SYSTEM IMPORT INBYTE, OUTBYTE, OUTWORD, AX, BX, CX, DX, ES,
       ADR, BP, GETREG, SETREG, SWI, ADDRESS, CODE, BYTE, WORD;
  FROM PointLib IMPORT Point, MakePoint;
  FROM Opcodes IMPORT PushBP, PopBP;
  TYPE
    Register =  RECORD CASE BOOLEAN OF TRUE : X : CARDINAL;
                                     | FALSE : L, H : CHAR; END; END;
    ByteADRType = RECORD
            CASE BOOLEAN OF  TRUE : adr : POINTER TO CHAR;
                           | FALSE : off, seg : CARDINAL; END; END;

  CONST
            TotalScanLinesEnhanced = 349;
            VIDEO = 10H;
            SetPageBiosCall = 005H;
            SetPaletteCall  = 010H;
            CharacterGeneratorFunction = 011H;
            WriteTTY = 00EH;
            SetCPos = 002H;
            AlphaPageSize = 2048;
            BottomOfScreen = 01FFH;

         (* This is the bit layout for Info and Info3 -- EGA
            information bytes found the Bios page *)
            CursorEmulateBit = 0;   MonoAttachedBit = 1;
            WaitForEnableBit = 2;   EGAIsActiveBit  = 3;
            MemoryBit1       = 5;   MemoryBit2      = 6;
            ModeSetClearBit  = 7;

            VerticalRetraceBit = 3;

         (* These are EGA IO registers *)
      Graph1          = 03CCh; Graph2          = 03CAh;
      Graph12         = 03CEh; MiscOut         = 03C2h;
      Status0         = 03C2h; Sequencer       = 03C4h;
      AttributeCntrl  = 03C0h; GraphData       = 03CFh;
      StatusRegisterOffset = 6;
         (* These are the names of the EGA indices *)
         (* Sequencer controller first *)
      SequenceReset     = 0;     SequenceClockMode = 1;
      SequenceMapMask   = 2;     SequenceCharMap   = 3;
      SequenceMemMode   = 4;
         (* CRT controller registers *)
      CRTHorizTotal     = 00h;   CRTHorizEnd       = 01h;
      CRTHorizBlStart   = 02h;   CRTHorizBlEnd     = 03h;
      CRTHorizRetStart  = 04h;   CRTHorizRetEnd    = 05h;
      CRTVertTotal      = 06h;   CRTOvflo          = 07h;
      CRTPreRowScan     = 08h;   CRTMaxScanLine    = 09h;
      CRTCursorStart    = 0Ah;   CRTCursorEnd      = 0Bh;
      CRTStartAddHi     = 0Ch;   CRTStartAddLo     = 0Dh;
      CRTCursLocHi      = 0Eh;   CRTCursLocLo      = 0Fh;
      CRTVertRetSt      = 10h;   CRTLightPenHi     = 10h;
      CRTVertRetEnd     = 11h;   CRTLightPenLo     = 11h;
      CRTVertDisEnd     = 12h;   CRTOffset         = 13h;
      CRTUnderLoc       = 14h;   CRTVertBlSt       = 15h;
      CRTVertBlEnd      = 16h;   CRTModeControl    = 17h;
      CRTLineCompare    = 18h;
         (* Graphics Controller indices *)
      GraphReset        = 00h;   GraphEnable       = 01h;
      GraphColorComp    = 02h;   GraphDataRotate   = 03h;
      GraphReadMapSel   = 04h;   GraphModeReg      = 05h;
      GraphMisc         = 06h;   GraphColorDC      = 07h;
      GraphBitMask      = 08h;
         (* Memory Mapping mode values *)
      A000x128K         = 00h;   A000x64K          = 04h;
      B000x32K          = 08h;   B800x32K          = 0Ch;
      GraphicsModeBit   = 01h;   ChainEvenToOdd    = 02h;
         (* Attribute Controller indices *)
      AttrModeControl   = 10h;   AttrOverscan      = 11h;
      AttrColorPlane    = 12h;   AttrHorizPelPan   = 13h;
      PaletteOn         = 20h;

  VAR
      VIDEORAM            : ByteADRType;
      bitmasks            : ARRAY [0..7] OF CARDINAL;
      Cursors             : ARRAY [0..7] OF Point;
      ActivePageOffsets   : ARRAY [0..7] OF CARDINAL;
      i                   : CARDINAL;
      CRTCOverflowRegister : BITSET;
      PelScrollColumn     : INTEGER;
      VerticalScrollRow   : INTEGER;
      SplitScreenLine     : CARDINAL;
      EGA6845             : CARDINAL;

(*$S-*)(*$T-*)(*$R-  Turn off Stack Checking for performance
                     and reentrancy reasons *)
  PROCEDURE EGAOutWord(EGAPort, DeviceRegister, Value : CARDINAL);
   (*Output two bytes to the EGA at two successive IO addresses *)
    VAR A : Register;
  BEGIN
    A.L := CHR(DeviceRegister); A.H := CHR(Value);
    OUTWORD(EGAPort, A.X);
  END EGAOutWord;
  PROCEDURE WaitForVerticalRetrace;
   (* Wait in a tight loop for vertical retrace *)
    VAR InputStatusRegister1 : BITSET;
  BEGIN
    REPEAT
        INBYTE(EGA6845 + StatusRegisterOffset,InputStatusRegister1);
    UNTIL VerticalRetraceBit IN InputStatusRegister1;
  END WaitForVerticalRetrace;

  PROCEDURE WaitForVerticalDisplay;
   (* Wait in a tight loop for vertical display active *)
    VAR InputStatusRegister1 : BITSET;
  BEGIN
    REPEAT
        INBYTE(EGA6845 + StatusRegisterOffset,InputStatusRegister1);
    UNTIL NOT (VerticalRetraceBit IN InputStatusRegister1);
  END WaitForVerticalDisplay;

  PROCEDURE SetPageOffset(where : CARDINAL);
   (* Instruct the CRTC where the page starts after retrace *)
    VAR   A : Register;
  BEGIN
    A.X := ActivePageOffset;
    WaitForVerticalRetrace;
    EGAOutWord(EGA6845, CRTStartAddHi,  ORD(A.H));
    EGAOutWord(EGA6845, CRTStartAddLo,  ORD(A.L));
  END SetPageOffset;

  PROCEDURE SetActiveFonts(FontA, FontB : CARDINAL);
   (* This routine changes the active character map for
      text modes. It is written as a reentrant procedure *)
    VAR x : CARDINAL;
  BEGIN
    x := FontA * 2 + FontB;
    WaitForVerticalRetrace;
    EGAOutWord(Sequencer, SequenceCharMap, x);
  END SetActiveFonts;
```

```
(*$S+*)(*$T+*)(*$R+ Turn run time services back on*)

PROCEDURE InitEGA(EGAMonitor : MonitorType) : BOOLEAN;
  (* This routine sets up the EGA for alpha Mode 3 *)
BEGIN
  SetUpAlpha;   MemoryInstalled := 0;
  IF MemoryBit2 IN EGABiosParams.InfoAndInfo3
     THEN MemoryInstalled := 2 END;
  IF MemoryBit1 IN EGABiosParams.InfoAndInfo3
     THEN INC(MemoryInstalled) END;
  IF EGAMonitor = Monochrome THEN
    IF MonoAttachedBit IN EGABiosParams.InfoAndInfo3 THEN
      EGA6845 := 03B4H;
    ELSE
      RETURN FALSE;
    END;
  ELSE
    IF NOT (MonoAttachedBit IN EGABiosParams.InfoAndInfo3) THEN
      EGA6845 := 03D4H;
    ELSE
      RETURN FALSE;
    END;
    RETURN TRUE;
  END;
END InitEGA;

PROCEDURE SetUpAlpha;
  (*This is a non standard set up to the EGA to Alpha
    80X25 on the graphics page (A000).  Assertion that EGA
    is already in mode 3 and EGA is configured with 256K RAM *)
  VAR
    a, b : Register;
BEGIN
   EGAOutWord(Graph12, GraphMisc,
         A000x64K + ChainEvenToOdd); (* Map to the A000 map *)
   EGAOutWord(EGA6845, CRTOvflo, 01FH);
   CRTCOverflowRegister := {4, 3, 2, 1, 0}
END SetUpAlpha;

PROCEDURE SetUpHiRes;
  (* This routine changes the EGA operating mode to HiRes color
     graphics. All of these register settings are from the
     boards' documentation  *)
BEGIN
  WaitForVerticalRetrace;
  EGAOutWord(Sequencer, SequenceMapMask,  00FH);
  EGAOutWord(Sequencer, SequenceMemMode,  006H);
  EGAOutWord(EGA6845, CRTHorizRetStart,  052H);
  EGAOutWord(EGA6845, CRTHorizRetEnd,  000H);
  EGAOutWord(EGA6845, CRTOvflo,  01FH);
  CRTCOverflowRegister := {4, 3, 2, 1, 0};
  ResetVerticalScroll;
  ResetSplitScreen;
  EGAOutWord(EGA6845, CRTMaxScanLine,  000H);
  EGAOutWord(EGA6845, CRTCursorStart,  01FH); (*Turn off cursor*)
  EGAOutWord(EGA6845, CRTCursorEnd,  000H);
  EGAOutWord(EGA6845, CRTVertBlSt,  05FH);
  EGAOutWord(EGA6845, CRTModeControl,  0E3H); (*Byte Mode *)
  EGAOutWord(EGA6845, CRTLineCompare,  0FFH);
  EGAOutWord(Graph12, GraphModeReg,  000H);
  EGAOutWord(Graph12, GraphMisc,  A000x64K + GraphicsModeBit);
  EGAOutWord(Graph12, GraphColorDC,  00FH);
  EGAOutWord(AttributeCntrl, AttrModeControl+PaletteOn, 001H);
  ResetHorizScroll;
  (* We are in writing mode 0 with all maps on this will
     clear out the display buffer *)
  FOR i := 0 TO 65500 DO DisplayBuffer[i] := 0C; END;
END SetUpHiRes;
(*-----------------------------------------------*)
(*        Position fiddling procedures           *)
(*           Warning for these routines:         *)
(*              Knowledge of exact mode          *)
(*              specifications including word/byte *)
(*              count by 2 etc is essential to using *)
(*              these routines                   *)
(*-----------------------------------------------*)

PROCEDURE SetLogicalRowSize(RowSizeInWords : CARDINAL);
  (* This routine sets the offset register of the CRTC. Word/byte
     issues play a role in its setting *)
BEGIN
  EGAOutWord(EGA6845, CRTOffset, RowSizeInWords);
END SetLogicalRowSize;

PROCEDURE SetUnderlineLocation(UnderlineScanLine : CARDINAL);
  (* Set the CRTC's scan line for underlining *)
BEGIN
  EGAOutWord(EGA6845, CRTUnderLoc, UnderlineScanLine);
END SetUnderlineLocation;

(*-----------------------------------------------------*)
(*      Mode Switching routines between the monitors  *)
(*      Warning -- Two monitor systems only           *)
(*                 Bad results can happen if on mono  *)
(*                   systems only!                    *)
(*-----------------------------------------------------*)

VAR
        EquipFlag     [0:410H]    : BITSET;

PROCEDURE SwitchToMonoBios;
  (* Adjust the Equipment Flag to indicate a Monochrome System *)
BEGIN
  EquipFlag := EquipFlag + {4, 5};
END SwitchToMonoBios;

PROCEDURE SwitchToColorBios;
  (* Adjust the Bios Equipment Flag to indicate Color system *)
BEGIN
  EquipFlag := EquipFlag - {4} + {5};
END SwitchToColorBios;

PROCEDURE ColorBiosMode() : BOOLEAN;
  (* Return the status of the Flag. False = Monochrome,
     true = Color. *)
BEGIN
  RETURN (NOT ((5 IN EquipFlag) AND (4 IN EquipFlag)));
END ColorBiosMode;
(*-----------------------------------------------------*)
(*   Cursor Routines                                   *)
(*-----------------------------------------------------*)

  PROCEDURE SetCursor(Page : CARDINAL);
    (* Set the Cursor to display for the given page *)
    VAR  Off : Register;
  BEGIN
    Off.X := CursorOffset(Page) DIV 2;
    EGAOutWord(EGA6845, CRTCursLocHi, ORD(Off.H));
    EGAOutWord(EGA6845, CRTCursLocLo, ORD(Off.L));
  END SetCursor;

  PROCEDURE CursorOffset(Page : CARDINAL) : CARDINAL;
    (* Calculate cursor offset for CPU mappings: which is doubled
       accouting for the attribute byte *)
  BEGIN
    RETURN ((ActivePageOffsets[Page] +
      CARDINAL(Cursors[Page].y) * ORD(BiosCRTParams.CRTCols) +
      CARDINAL(Cursors[Page].x)) * 2);
  END CursorOffset;

  PROCEDURE BumpCursor(Page : CARDINAL);
    (*Increment the cursor in the X direction one unit. If the cursor
      falls off the row, reset to the beginning of the next row. Rows
      wrap around to the start of the screen *)
  BEGIN
    INC(Cursors[Page].x);
    IF Cursors[Page].x >= INTEGER(BiosCRTParams.CRTCols) THEN
      Cursors[Page].x := 0;
      INC(Cursors[Page].y);
      IF ORD(Cursors[Page].y) > ORD(RowsOnScreen) THEN
        Cursors[Page].y := 0;
      END;
    END;
    IF Page = ActivePage THEN SetCursor(Page); END;
  END BumpCursor;

  PROCEDURE SetCursorPoint(Page : CARDINAL; p : Point);
    (* Set the cursor to point 'p'. Don't allow it to fall off
       either edge of the display *)
  BEGIN
    IF p.x < INTEGER(BiosCRTParams.CRTCols) THEN
      Cursors[Page].x := p.x;
```

```
ELSE
  Cursors[Page].x := INTEGER(BiosCRTParams.CRTCols) - 1;
END;
IF p.y <= INTEGER(ORD(RowsOnScreen)) THEN
  Cursors[Page].y := p.y;
ELSE
  Cursors[Page].y := ORD(RowsOnScreen);
END;
IF Page = ActivePage THEN SetCursor(Page); END;
END SetCursorPoint;

PROCEDURE GetCursorPoint(VAR p : Point; Page : CARDINAL);
  (* Return the cursor position for the given page *)
BEGIN
  p := Cursors[Page];
END GetCursorPoint;


(*--------------------------------------------------*)
(*    Alpha mode write routines                      *)
(*--------------------------------------------------*)

PROCEDURE Write(Page : CARDINAL; ch : CHAR; color : INTEGER);
  (* Place one character into the display buffer at the
     cursor. The cursor in moved to the next column.
     Color represents the attribute byte *)
  VAR   x : CARDINAL;
BEGIN
  x := CursorOffset(Page);
  DisplayBuffer[x] := ch;
  DisplayBuffer[x+1] := CHR(color);
  BumpCursor(Page);
END Write;

PROCEDURE WriteString(Page: CARDINAL; s : ARRAY OF CHAR;
                      c : CARDINAL);
  (* Place a string into the display buffer at the cursor.
     The string is written one character at a time with
     the attribute byte of c *)
  VAR i : CARDINAL;
BEGIN
  i := 0;
  WHILE i <= HIGH(s) DO
    Write(Page, s[i], c);
    INC(i);
  END;
END WriteString;

(*--------------------------------------------------*)
(*    Virtual page manipulation routines             *)
(*--------------------------------------------------*)

PROCEDURE SetActivePage(page : CARDINAL);
  (* Set the active display page to 'page' resetting
     any scrolling etc. *)
BEGIN
  ActivePage := page;
  ResetHorizScroll;
  ResetVerticalScroll;
  IF page <= MaxVideoPages THEN
    ActivePageOffset := ActivePageOffsets[page];
    SetPageOffset(ActivePageOffset);
    SetCursor(page);
  END;
END SetActivePage;

PROCEDURE MakeSecondGraphicsPage;
  (* This routine arbitrarily sets the offset to the
     second hi res graphics page *)
BEGIN
  ActivePageOffset := 8000H;
  SetPageOffset(ActivePageOffset);
  SetBiosPage(1);
END MakeSecondGraphicsPage;

PROCEDURE ResetVideoPage;
  (*This routine resets the current video page, and
    get rid of any scrolling and split screens, etc.*)
BEGIN
  SetActivePage(ActivePage);
  ResetSplitScreen;
END ResetVideoPage;
(*--------------------------------------------------*)
(*      Attribute manipulation routines              *)
(*--------------------------------------------------*)

PROCEDURE SetPalette(Palette, Color : CARDINAL);
  (* This routine sets up the palette RAM in the
     attribute controller with the pattern in Color *)
BEGIN
  WaitForVerticalRetrace;
  EGAOutWord(AttributeCntrl, Palette, Color);
  EGAOutWord(AttributeCntrl, AttrColorPlane+PaletteOn, 0FH);
END SetPalette;

PROCEDURE SetOverscan(Color : CARDINAL);
  (* This routine sets up the overscan color for a border
     with the pattern in Color *)
BEGIN
  WaitForVerticalRetrace;
  EGAOutWord(AttributeCntrl, AttrOverscan, Color);
  EGAOutWord(AttributeCntrl, AttrColorPlane+PaletteOn, 0FH);
END SetOverscan;

PROCEDURE TurnOnBlinking;
BEGIN
  EGAOutWord(AttributeCntrl, AttrModeControl+PaletteOn, 09H);
END TurnOnBlinking;

PROCEDURE TurnOffBlinking;
BEGIN
  EGAOutWord(AttributeCntrl, AttrModeControl+PaletteOn, 01H);
END TurnOffBlinking;
(*--------------------------------------------------*)
(*     Horizontal scrolling routines                 *)
(*--------------------------------------------------*)

PROCEDURE HorScrollLeft;
  (* Horizontal scrolling left means advancing the page offset
     when falling off the pixel box. The routine is specific
     for 8 pixels per byte  *)
BEGIN
  INC(PelScrollColumn);
  WaitForVerticalDisplay;
  IF PelScrollColumn > 7 THEN
    PelScrollColumn := 0;
    INC(ActivePageOffset);
    SetPageOffset(ActivePageOffset);  (* Does a Wait already*)
    EGAOutWord(AttributeCntrl, AttrHorizPelPan+PaletteOn,
               PelScrollColumn);
  ELSE;
    WaitForVerticalRetrace;
    EGAOutWord(AttributeCntrl, AttrHorizPelPan+PaletteOn,
               PelScrollColumn);
  END;
END HorScrollLeft;

PROCEDURE HorScrollRight;
BEGIN
  DEC(PelScrollColumn);
  WaitForVerticalDisplay;
  IF PelScrollColumn < 0 THEN
    PelScrollColumn := 7;
    DEC(ActivePageOffset);
    SetPageOffset(ActivePageOffset);
    EGAOutWord(AttributeCntrl, AttrHorizPelPan+PaletteOn,
               PelScrollColumn);
  ELSE
    WaitForVerticalRetrace;
    EGAOutWord(AttributeCntrl, AttrHorizPelPan+PaletteOn,
               PelScrollColumn);
  END;
END HorScrollRight;

PROCEDURE HorizScroll(pixels : INTEGER);
  VAR i : INTEGER;
BEGIN
  IF pixels = 0 THEN RETURN; END;
  IF pixels > 0 THEN
    FOR i := 1 TO pixels DO HorScrollLeft; END;
  ELSE
    FOR i := -1 TO pixels BY -1 DO HorScrollRight; END;
```

```
  END;
END HorizScroll;

PROCEDURE ResetHorizScroll;
BEGIN
  PelScrollColumn := 0;
  WaitForVerticalRetrace;
  EGAOutWord(AttributeCntrl, AttrHorizPelPan+PaletteOn, 0);
END ResetHorizScroll;

   (*---------------------------------------------*)
   (*        Vertical Scrolling                   *)
   (*     only has meaning in alpha modes         *)
   (*---------------------------------------------*)

PROCEDURE VerticalScrollUp;
  (* Smooth vertical scroll uses the Preset row scan register
     in the CRTC. When the row is completely scrolled,
     the offset pointer is advanced by one row size *)
BEGIN
  INC(VerticalScrollRow);  WaitForVerticalDisplay;
  IF VerticalScrollRow >= INTEGER(BytesPerChar) THEN
    ActivePageOffset := ActivePageOffset + BiosCRTParams.CRTCols;
    VerticalScrollRow := 0;
    SetPageOffset(ActivePageOffset);
    EGAOutWord(EGA6845, CRTPreRowScan, VerticalScrollRow);
  ELSE
    WaitForVerticalRetrace;
    EGAOutWord(EGA6845, CRTPreRowScan, VerticalScrollRow);
  END;
END VerticalScrollUp;

PROCEDURE VerticalScrollDown;
  (* Vertical Scrolling down is the same as up except the row
     changes backward, each character row is brought down a line
     at a time by setting the preset row scan register to the
     high value and decrementing it. *)
BEGIN
  DEC(VerticalScrollRow);  WaitForVerticalDisplay;
  IF VerticalScrollRow < 0 THEN
    ActivePageOffset := ActivePageOffset - BiosCRTParams.CRTCols;
    VerticalScrollRow := BytesPerChar - 1;
    SetPageOffset(ActivePageOffset);
    EGAOutWord(EGA6845, CRTPreRowScan, VerticalScrollRow);
  ELSE
    WaitForVerticalRetrace;
    EGAOutWord(EGA6845, CRTPreRowScan, VerticalScrollRow);
  END;
END VerticalScrollDown;

PROCEDURE ResetVerticalScroll;
BEGIN
  WaitForVerticalRetrace;
  EGAOutWord(EGA6845, CRTPreRowScan,  0);
  VerticalScrollRow := 0;
END ResetVerticalScroll;
(*--------------------------------------------------*)
(*     Split screen routines                        *)
(*          The split screen starts at offset in the *)
(*           display buffer                         *)
(*--------------------------------------------------*)

PROCEDURE SplitScreenAt(ScanLine : CARDINAL);
  (* Splitting the screen uses the Line Compare Register of
     the CRTC. The overflow for the 9th bit is placed in the
     CRTC'c overflow register. The screen splits when the
     current video scan line equals the designated value
     in those two registers  *)
  VAR Line : Register;
BEGIN
  Line.X := ScanLine;
  IF Line.H <> 0C THEN
    CRTCOverflowRegister := CRTCOverflowRegister + {4};
  ELSE
    CRTCOverflowRegister := CRTCOverflowRegister - {4}; END;
  WaitForVerticalDisplay;  WaitForVerticalRetrace;
  EGAOutWord(EGA6845, CRTLineCompare, ORD(Line.L));
  EGAOutWord(EGA6845, CRTOvflo,
           CARDINAL(CRTCOverflowRegister));
  SplitScreenLine := ScanLine;
END SplitScreenAt;

PROCEDURE RollSplitScreenUp(SplitSizeLines : CARDINAL);
  (* Smoothly bring up the split screen with a delay between
     each line as it is brought up.  *)
  VAR Line : CARDINAL;
BEGIN
  Line := TotalVerticalScanLines - 1;
  WHILE Line > TotalVerticalScanLines - SplitSizeLines DO
    SplitScreenAt(Line);
    DEC(Line);
    WaitForVerticalRetrace;
  END;
END RollSplitScreenUp;

PROCEDURE RollSplitScreenDown;
  (* This routines smoothly rolls the split screen back down *)
  VAR Line : CARDINAL;
BEGIN
  Line := SplitScreenLine + 1;
  WHILE Line < TotalVerticalScanLines DO
    SplitScreenAt(Line);
    INC(Line);
    WaitForVerticalRetrace;
  END;
END RollSplitScreenDown;
PROCEDURE ResetSplitScreen;
  (* This routine pops the split screen back down, no scrolling
     is performed. *)
BEGIN
  SplitScreenAt(BottomOfScreen);
END ResetSplitScreen;

(*--------------------------------------------------*)
(*       Graphics routines                          *)
(*--------------------------------------------------*)

PROCEDURE FillGraphicsPage(Color : CARDINAL);
   (* Modify to use writing mode 2: Set every bit in bit plane N
      equal to bit N of the data bytes. Useful for rapid flooding
      of the display ram with a particular palette. *)
   VAR x1, y1 : CARDINAL;
BEGIN
  EGAOutWord(Graph12, GraphModeReg, 2);
  FOR x1 := 0 TO BiosCRTParams.CRTCols - 1 DO
    FOR y1 := 0 TO 349 DO
      DisplayBuffer[ActivePageOffset + x1 +
                    BiosCRTParams.CRTCols * y1] := CHR(Color);
    END;
  END;
  EGAOutWord(Graph12, GraphModeReg, 0)
END FillGraphicsPage;

PROCEDURE DrawPointTutorial(p : Point; color : CARDINAL);
(* This procedure demonstrates the method for turing on
   one pixel. A faster version is below with key parts reduced
   to machine level code *)
(* Turn on a dot at 'p', setting its 'color'. *)
  VAR  rowbyte, bitmask, byteoffset : CARDINAL;
       Temp : CHAR;
BEGIN
  (* Here compute the address of the pixel byte to change,
     and its bit offset within the byte. *)
  rowbyte := p.x DIV 8;  bitmask := p.x MOD 8;
  bitmask := bitmasks[bitmask];
  byteoffset := CARDINAL(p.y) * BiosCRTParams.CRTCols + rowbyte
                + ActivePageOffset;
  VIDEORAM.off := byteoffset;
  (*  Select Graphics Bit Mask Register to mask
      out all but the desired pixel *)
  EGAOutWord(Graph12, GraphBitMask, bitmask);
  (*  Select sequencer map mask to enable all four
      maps and latches even if 2 are present *)
  EGAOutWord(Sequencer, SequenceMapMask, 0FH);
  (* Now read the character to latch it in to the 4 EGA plane
     latches. The value read is of no importance *)
  Temp := VIDEORAM.adr^;
  (* Now blank out the all bytes, to clear out the desired
     pixel. Remember the other bits are still latched in, and
     will be preserved during this operation. *)
  VIDEORAM.adr^ := 0c;
  (* Select sequencer Map Mask to enable only writing to those
```

```
    bit planes with bits corresponding to the selected palette *)
  EGAOutWord(Sequencer, SequenceMapMask, color);
  (* Now write all bits out in parallel. The sequencer map
     mask and the board latches preserve all pixels except
     that to be set. *)
  VIDEORAM.adr^ := CHR(0FFH);
  (* Normalize the environment, by resetting the masks and
     the data rotation register *)
  EGAOutWord(Sequencer, SequenceMapMask, 0FH);
  EGAOutWord(Graph12, GraphDataRotate, 0);
  EGAOutWord(Graph12, GraphBitMask, 0FFH);
END DrawPointTutorial;

(*$R-*)(*$S-*)(*$T-*)  (*Turn off overhead calls for speed *)

 PROCEDURE DrawPoint(p : Point; color : CARDINAL);
 (* Turn on a dot at 'p', with setting color *)
  VAR
    A : Register;
    rowbyte, bitmask, byteoffset : CARDINAL;
 BEGIN
   rowbyte := p.x DIV 8; (* After a divide dx has modulus *)
   GETREG(DX, bitmask);
   bitmask := bitmasks[bitmask];
   byteoffset := CARDINAL(p.y) * BiosCRTParams.CRTCols + rowbyte
                 + ActivePageOffset;
   SETREG(ES, VIDEORAM.seg);    SETREG(BX, byteoffset);
   SETREG(CX, color);           SETREG(AX, bitmask);
   CODE ( 88h, 0c4h, 0b0h, 08h, 0bah, 0ceh, 03h, 0efh, 0b8h, 02h,
        0ffh, 0b2h, 0c4h, 0efh, 26h, 08ah, 2fh, 26h, 0c6h, 07h,
        00h, 88h, 0cch, 0efh, 026h, 0c6h, 07h, 0ffh, 0b4h, 0ffh,
        0efh, 0b2h, 0ceh, 0b8h, 03h, 00h, 0efh, 0b8h, 08h, 0ffh,
        0efh);
 END DrawPoint;

(*$R+*)(*$S+*)(*$T+*)

(*---------------------------------------------------*)
(*          BIOS Interface Routines                   *)
(*---------------------------------------------------*)

PROCEDURE LoadBiosFont(Font : FontType; ResetFlag : BOOLEAN;
                       Block : CARDINAL);
  VAR A : Register;
BEGIN
  A.H := CHR(CharacterGeneratorFunction);
  A.L := CHR(ORD(Font));
  IF ResetFlag THEN A.L := CHR(ORD(A.L) + 011H);
               ELSE A.L := CHR(ORD(A.L) + 01H) END;
  SETREG(AX, A.X);
  SETREG(BX, Block);
  SWI(VIDEO);
END LoadBiosFont;

PROCEDURE LoadUserFont(VAR Font : ARRAY OF CHAR; ResetFlag : BOOLEAN;
                       Block, Count, Points : CARDINAL);
  VAR A, B : Register;
      f : ADDRESS;
BEGIN
  f := ADR(Font);
  A.H := CHR(CharacterGeneratorFunction);
  IF ResetFlag THEN A.L := CHR(010H);
               ELSE A.L := CHR(00H) END;
  B.H := CHR(Points);      B.L := CHR(Block);
  SETREG(CX, Count);       SETREG(BX, B.X);
  SETREG(AX, A.X);         CODE(PushBP); (*Save our BP *)
  SETREG(ES, f.SEGMENT); SETREG(DX, f.OFFSET);
  CODE(89H, 0D5H); (* MOV bp, dx ;Set BP to point at font *)
  SETREG(DX, 0);           SWI(VIDEO);
  CODE(PopBP);  (*Restore the BP *)
END LoadUserFont;

PROCEDURE GetAlternatePrintScreen;
BEGIN
  SETREG(AX, 01200H);     SETREG(BX, 0020H);
  SWI(VIDEO);
END GetAlternatePrintScreen;

PROCEDURE SetBiosPage(Page : CARDINAL);
  VAR A : Register;
BEGIN
  A.H := CHR(SetPageBiosCall); A.L := CHR(Page);
  SETREG(AX, A.X); SWI(VIDEO);
END SetBiosPage;

PROCEDURE SetBiosPalette(Palette, Color : CARDINAL);
  VAR A, B : Register;
BEGIN
  A.H := CHR(SetPaletteCall); A.L := 0C;
  B.H := CHR(Color); B.L := CHR(Palette);
  SETREG(BX, B.X); SETREG(AX, A.X);
  SWI(VIDEO);
END SetBiosPalette;

PROCEDURE SetModeBios(Mode : CARDINAL);
BEGIN
  SETREG (AX, Mode);
  SWI(VIDEO);
END SetModeBios;

PROCEDURE SetBiosCursorPoint(Page : CARDINAL; p : Point);
  VAR A, B, D : Register;
BEGIN
  A.H := CHR(SetCPos);  A.L := 0C;
  B.H := CHR(Page);     B.L := 0C;
  D.H := CHR(p.y);      D.L := CHR(p.x);
  SETREG(DX, D.X);      SETREG(BX, B.X);
  SETREG(AX, A.X);      SWI(VIDEO);
END SetBiosCursorPoint;

PROCEDURE WriteBios(c : CHAR; color : CARDINAL);
  VAR A, B : Register;
BEGIN
  A.H := CHR(WriteTTY); A.L := c;
  B.H := 0C;            B.L := CHR(color);
  SETREG(BX, B.X);      SETREG(AX, A.X);
  SWI(VIDEO);
END WriteBios;

PROCEDURE WriteBiosString(msg : ARRAY OF CHAR; color : CARDINAL);
   VAR i : CARDINAL;
BEGIN
  i := 0;
  WHILE i <= HIGH(msg) DO
    WriteBios(msg[i], color);
    INC(i);
  END;
END WriteBiosString;

PROCEDURE PrintScreen;
BEGIN
  SWI(05H);
END PrintScreen;


BEGIN
  VIDEORAM.seg := 0a000H;    VIDEORAM.off := 0;
  bitmasks[7] := 1;          bitmasks[6] := 2;
  bitmasks[5] := 4;          bitmasks[4] := 8;
  bitmasks[3] := 16;         bitmasks[2] := 32;
  bitmasks[1] := 64;         bitmasks[0] := 128;
  MakePoint(Cursors[0], 0, 0);
  FOR i := 1 TO MaxVideoPages DO Cursors[i] := Cursors[0]; END;
  FOR i := 0 TO MaxVideoPages DO
       ActivePageOffsets[i] := i * AlphaPageSize; END;
  PelScrollColumn := 0; VerticalScrollRow := 0;
  TotalVerticalScanLines := TotalScanLinesEnhanced;
  ActivePage := 0;
END LowEGA.
```

LISTING 3: DRAWPOLY.DEF

```
DEFINITION MODULE DrawPoly;
(*
Title    : DrawPoly.DEF -- Draw lines and boxes
LastEdit: July 22, 1986
Author   : John T. Cockerham, M.D.
System   : LOGITECH MODULA-2/86
*)
  FROM LowEGA IMPORT DrawPoint;
  FROM PointLib IMPORT Point;
  EXPORT QUALIFIED DrawLine, DrawBox;
```

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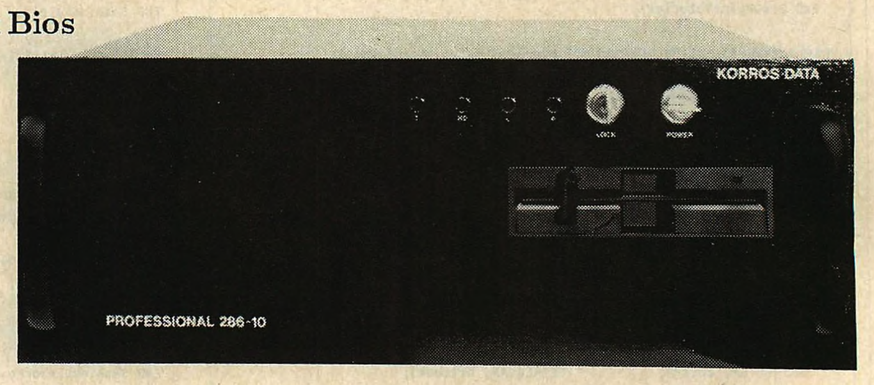

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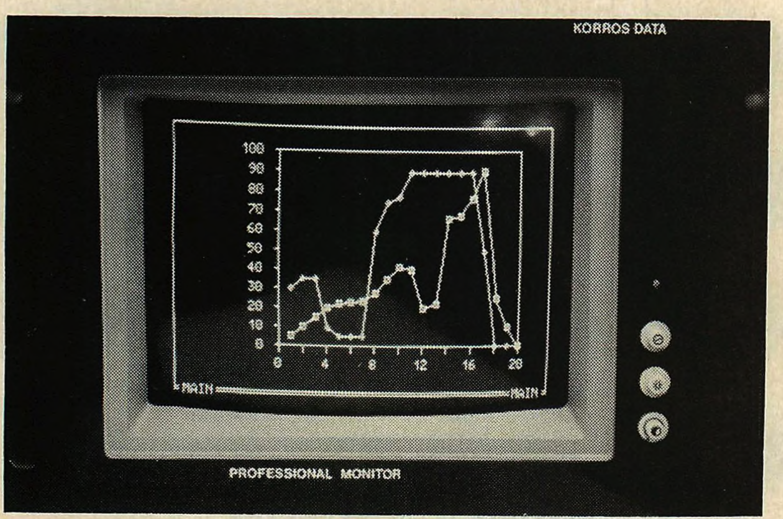

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```
    (*Draw a line from p1 to p2 in color 'color' *)
  PROCEDURE DrawLine(p1, p2 : Point; color : CARDINAL);

    (* Draw a Box with the two points specifying two opposite
       corners. Color the lines according to palette c *)
  PROCEDURE DrawBox(UpperLeft, LowerRight : Point; c : CARDINAL);
END DrawPoly.
```

LISTING 3a: DRAWPOLY.MOD

```
IMPLEMENTATION MODULE DrawPoly;
(*
Title    : DrawPoly.MOD -- Draw lines and boxes
LastEdit: July 22, 1986
Author  : John T. Cockerham, M.D.
System  : LOGITECH MODULA-2/86
*)
  FROM LowEGA IMPORT DrawPoint;
  FROM PointLib IMPORT Point;

  PROCEDURE DrawLine(p1, p2 : Point; color : CARDINAL);
    (* Brensheman's Algorithm for drawing a line from
       p1 to p2. *)
    VAR deltax, deltay, xup, yup, supx, supy,
        temp, corrs, corrd, direction, maxdim, i : INTEGER;
        a : Point;
  BEGIN
    xup := 1;  yup := 1;
    deltax := p2.x-p1.x;  deltay := p2.y-p1.y;
    IF deltax < 0 THEN xup := -1; deltax := -deltax;  END;
    IF deltay < 0 THEN yup := -1; deltay := -deltay;  END;
    supx := xup;  supy := yup;   maxdim := deltax;
    IF deltax < deltay THEN
      maxdim := deltay;      supx := 0;
      temp := deltax;        deltax := deltay;
      deltay := temp;
    ELSE
      supy := 0;
    END;
    corrs := 2 * deltay;  corrd := 2 * (deltay - deltax);
    direction := (2 * deltay) - deltax;
    a := p1;
    FOR i := 1 TO maxdim DO
      DrawPoint(a, color);
      IF direction >= 0 THEN
        a.x := a.x + xup;  a.y := a.y + yup;
        direction := direction + corrd;
      ELSE
        a.x := a.x + supx; a.y := a.y + supy;
        direction := direction + corrs;
      END;
    END;
  END DrawLine;

  PROCEDURE DrawBox(UpperLeft, LowerRight : Point; c : CARDINAL);
    (* Draw a Box with the two points specifying two opposite
       corners. Color the lines according to palette c *)
    VAR    p1, p2 : Point;
  BEGIN
    p1 := UpperLeft;  p2 := LowerRight;     p2.x := UpperLeft.x;
    DrawLine(p1, p2, c);
    p2 := LowerRight; p2.y := UpperLeft.y;  DrawLine(p1, p2, c);
    p1 := LowerRight; p2 := UpperLeft;      p2.x := LowerRight.x;
    DrawLine(p1, p2, c);
    p2 := UpperLeft;  p2.y := LowerRight.y; DrawLine(p1, p2, c);
  END DrawBox;
END DrawPoly.
```

LISTING 4: FONTBUMP.DEF

```
DEFINITION MODULE FontBumper;
(*
Title    : FontBumper.DEF
LastEdit: July 22, 1986
Author  : John T. Cockerham, M.D.
System  : LOGITECH MODULA-2/86
*)
  EXPORT QUALIFIED SetUpFontBumping, ResetFontBumping;

  PROCEDURE SetUpFontBumping(Rate : CARDINAL) : BOOLEAN;
  PROCEDURE ResetFontBumping;


END FontBumper.
```

LISTING 4a: FONTBUMP.MOD

```
IMPLEMENTATION MODULE FontBumper;
(*
Title    : FontBumper.mod
LastEdit: June 5, 1986
Author  : John T. Cockerham, M.D.
System  : LOGITECH MODULA-2/86
*)
  FROM SYSTEM IMPORT CODE, ADDRESS, ADR, DOSCALL, SETREG, ES, BX,
              DISABLE;
  FROM FileSystem IMPORT File, Lookup, ReadNBytes, Close, Response;
  FROM LowEGA IMPORT SetActiveFonts, LoadBiosFont, FontType,
       SetUpAlpha, SetModeBios, WaitForVerticalRetrace, LoadUserFont;
  FROM Opcodes IMPORT PushAX, PushBX, PushCX, PushDX, PushBP, PushES,
       PushDS, PushFlags, PushSI, PushDI, PopAX, PopBX, PopCX, PopDX,
       PopSI, PopDI, PopBP, PopES, PopDS, Iret;
  FROM Pauses IMPORT Pause;
  CONST
       TimeHack      = 01CH;
       GetIntVector = 035H;
       SetIntVector = 025H;
       PreserveBit  = 080H;
       AlphaMode     = 003H;

  (* These are static variables preserved across interrupts *)
  VAR CurrentFont        : CARDINAL;
      OldTimerVector     : ADDRESS;
      PointerToOldVector : ADDRESS;
      FontBumpX          : PROCEDURE;
      FontBumpY          : ADDRESS;
      Count              : CARDINAL;
      AnotherFont        : ARRAY [0 .. 0E00H] OF CHAR;
      FontFile           : File;
      ChangeRate         : CARDINAL;


    (*$R-*)(*$S-*)(*$T-*)
    (* This routine is meant to run as a separate interrupt handler.
       At each time tick, the handler bumps a counter. When the
       counter exceeds the variable ChangeRate, it changes the active
       font on the EGA. It is installed when font bumping is turned
       on.  Disabling the M2 run time services makes the routine
       fully reentrant. *)
    PROCEDURE FontBump;
    BEGIN
      (* Compiler generated push bp. Save all of our registers  *)
      CODE (PushAX, PushCX, PushDX, PushBX, PushSI,
            PushDI, PushES, PushDS);
      IF Count >= ChangeRate THEN
        SetActiveFonts(CurrentFont, CurrentFont);
        INC(CurrentFont);
        IF CurrentFont > 3 THEN CurrentFont := 0; END;
        Count := 0;
      END;
      INC(Count);
      SETREG(ES, PointerToOldVector.SEGMENT);
      SETREG(BX, PointerToOldVector.OFFSET);
      (* Here fudge the stack to look like an interrupt
         by pushing the flags on the stack, then calling
         es:bx who will return to us after the "call" which
         looks like an interrupt. *)
      CODE(PushFlags, 026H, 0FFH, 01FH);
      (* Now set up to return from interrupt *)
      CODE (PopDS, PopES, PopDI, PopSI, PopBX, PopDX, PopCX, PopAX,
            (*Mov sp,bp *) 89H, 0ECH, PopBP, Iret);
    END FontBump;
    (*$R+*)(*$S+*)(*$T+*)

    PROCEDURE GetUserFont(VAR Destination : ARRAY OF CHAR;
                          FileName : ARRAY OF CHAR;
                          NumberOfChars : CARDINAL;
                          Points : CARDINAL) : BOOLEAN;
```

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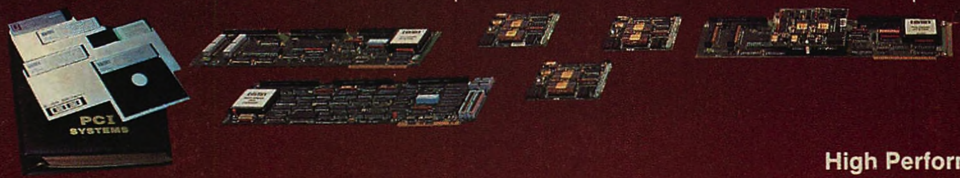

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CIRCLE NO. 117 ON READER SERVICE CARD

```
  VAR NewFile : BOOLEAN;
      ActuallyRead : CARDINAL;
BEGIN
  NewFile := FALSE;
  Lookup(FontFile, FileName, NewFile);
  IF FontFile.res = notdone THEN
      Pause('Unable to read "othrfont.dat"');
      RETURN FALSE;
  END;
  ReadNBytes(FontFile, ADR(Destination), NumberOfChars * Points,
             ActuallyRead);
  Close(FontFile);
  RETURN TRUE;
END GetUserFont;

PROCEDURE SetUpFontBumping(Rate : CARDINAL) : BOOLEAN;
BEGIN
  ChangeRate := Rate;
  IF GetUserFont(AnotherFont, 'othrfont.dat', 0100H, 0EH) THEN
    SetModeBios(AlphaMode + PreserveBit);
    LoadBiosFont(MonochromeFont, FALSE, 1);
    WaitForVerticalRetrace;
    SetModeBios(AlphaMode + PreserveBit);
    LoadUserFont(AnotherFont, FALSE, 2, 0100H, 0EH);
    WaitForVerticalRetrace;
    SetModeBios(AlphaMode + PreserveBit);
    LoadUserFont(AnotherFont, FALSE, 3, 0100H, 0EH);
    WaitForVerticalRetrace;
    DOSCALL(GetIntVector, TimeHack, OldTimerVector);
    DOSCALL(SetIntVector, FontBumpY, TimeHack);
    SetUpAlpha;
    RETURN TRUE;
  ELSE
    RETURN FALSE;
  END;
    END SetUpFontBumping;

    PROCEDURE ResetFontBumping;
    BEGIN
      DOSCALL(SetIntVector, OldTimerVector, TimeHack);
      SetActiveFonts(0, 0);
    END ResetFontBumping;

BEGIN
  CurrentFont := 0;
  ChangeRate := 4;
  Count := 0;
  PointerToOldVector := ADR(OldTimerVector);
  FontBumpX := FontBump;
  FontBumpY := ADDRESS(FontBumpX);
END FontBumper.
```

LISTING 5: DOTTIME.DEF

```
DEFINITION MODULE DotTime;
  EXPORT QUALIFIED DotTimingTest;
  PROCEDURE DotTimingTest;
END DotTime.
```

LISTING 5a: DOTTIME.MOD

```
IMPLEMENTATION MODULE DotTime;


  IMPORT Terminal;
  FROM SYSTEM IMPORT AX, BX, CX, DX, ES, SWI, GETREG, SETREG, CODE,
       ADR;
  FROM LowEGA IMPORT SetModeBios, SetUpHiRes, SetUpAlpha, DrawPoint,
       SetBiosCursorPoint, BiosCRTParams;
  FROM TimeDate IMPORT GetTime, Time;
  FROM RealConversions IMPORT RealToString;
  FROM PointLib IMPORT Point, MakePoint;
  FROM Pauses IMPORT Pause;

  CONST
      HiRes = 010H;    (* Color Hi Res Mode *)
      Alpha = 003H;    (* Color Alpha Mode  *)
      VIDEO = 010H;    (* Video Interrupt   *)
      Page0 = 0H;
      DisplayPageAddr = 0A000H;

  PROCEDURE DotTimingTest;
    (* This routine paints 65000 pixels on the CRT in three ways.
       The time for each method is recorded for the user to see *)
    VAR t1               : REAL;
        l1               : ARRAY [0..50] OF CHAR;
        ok               : BOOLEAN;
        j, rowbyte       : CARDINAL;
        bitmasks         : ARRAY [0..7] OF CARDINAL;
        Times            : ARRAY [0..5] OF Time;
        byteoff,bitmask  : CARDINAL;
        p                : Point;

      PROCEDURE MakeTime(Stop, Start : CARDINAL);
        VAR mins : CARDINAL;
      BEGIN
        mins := Times[Stop].minute - Times[Start].minute;
        t1 := FLOAT(mins) * 60000. + FLOAT(Times[Stop].millisec)
                FLOAT(Times[Start].millisec);
        t1 := t1 / 1000.;
        RealToString(t1, 3, 7, l1, ok);
        Terminal.WriteString(l1);   Terminal.WriteLn;
      END MakeTime;

    BEGIN
      bitmasks[7] := 1;          bitmasks[6] := 2;
      bitmasks[5] := 4;          bitmasks[4] := 8;
      bitmasks[3] := 16;         bitmasks[2] := 32;
      bitmasks[1] := 64;         bitmasks[0] := 128;
      Pause('Dot Timing Test');
      SetModeBios(HiRes);        SetUpHiRes;

        (* The first test -- direct subroutine call *)
      MakePoint(p, 25, 25);    GetTime(Times[0]);
      FOR j := 0 TO 65000 DO
        DrawPoint(p, 4);
      END;
      GetTime(Times[1]);

        (* Test #2 -- Bios calls *)
      MakePoint(p, 50, 50);    GetTime(Times[2]);
      FOR j := 0 TO 65000 DO
        SETREG(BX, 0);           SETREG(AX, 0C02h);
        SETREG(CX, p.x);         SETREG(DX, p.y);
        SWI(VIDEO);
      END;
      GetTime(Times[3]);

       (* Test #3 -- direct inline assembler code *)
      MakePoint(p, 75, 75);    GetTime(Times[4]);
      FOR j := 0 TO 65000 DO
        rowbyte := p.x DIV 8;  GETREG(DX, bitmask);
        bitmask := bitmasks[bitmask];
        byteoff := CARDINAL(p.y) * BiosCRTParams.CRTCols + rowbyte;
        SETREG(ES, DisplayPageAddr);    SETREG(BX, byteoff);
        SETREG(CX, 1);                  SETREG(AX, bitmask);
        CODE(88h, 0c4h, 0b0h, 08h, 0bah, 0ceh, 03h, 0efh, 0b8h, 02h,
            0ffh, 0b2h, 0c4h, 0efh, 26h, 08ah, 2fh, 26h, 0c6h, 07h,
            00h, 88h, 0cch, 0efh, 026h, 0c6h, 07h, 0ffh, 0b4h, 0ffh,
            0efh, 0b2h, 0ceh, 0b8h, 03h, 00h, 0efh, 0b8h, 08h, 0ffh,
            0efh);
      END;
      GetTime(Times[5]);

        (* Now to report the results on the screen *)
      SetModeBios(Alpha);
      MakePoint(p, 0, 6); SetBiosCursorPoint(Page0, p);
      Terminal.WriteString('Subroutine time = ');
      MakeTime(1, 0);
      Terminal.WriteString('EGA BIOS time = ');
      MakeTime(3, 2);
      Terminal.WriteString('Direct In Line Code Time = ');
      MakeTime(5, 4);
      SetUpAlpha;
      Pause('End Dot Timing Test');
    END DotTimingTest;
END DotTime.
```

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LISTING 6: PAUSES.DEF

```
DEFINITION MODULE Pauses;
(*
Title   : Pauses.DEF -- SplitScreen Pauses
LastEdit: July 22, 1986
Author  : John T. Cockerham, M.D.
System  : LOGITECH MODULA-2/86
*)
  EXPORT QUALIFIED Pause, GraphicsPause;

  (* This procedure raises a split screen and prints a message there
     awaiting the user to continue. Can only be used text mode. *)
  PROCEDURE Pause(msg : ARRAY OF CHAR);

  (* This procedure is the pausing procedure in graphics modes *)
  PROCEDURE GraphicsPause (Page : CARDINAL; msg : ARRAY OF CHAR);
END Pauses.
```

LISTING 6a: PAUSES.MOD

```
IMPLEMENTATION MODULE Pauses;
(*
Title   : Pauses.MOD -- SplitScreen Pauses
LastEdit: July 22, 1986
Author  : John T. Cockerham, M.D.
System  : LOGITECH MODULA-2/86
*)
IMPORT Terminal;
FROM LowEGA IMPORT
  Write, WriteString, SetCursorPoint, SetCursor, GetCursorPoint,
  RollSplitScreenUp, WriteBiosString, RollSplitScreenDown,
  SetBiosCursorPoint, SetModeBios, ActivePage;
FROM PointLib IMPORT Point, MakePoint, BumpPointY;

CONST Page0 = 0; Blank = 020H;

  (* This procedure raises a split screen and prints a message there
     awaiting the user to continue. Can only be used text mode. *)
  PROCEDURE Pause(msg : ARRAY OF CHAR);
    VAR ch : CHAR;     p : Point;
        SavedCursor : Point;

    PROCEDURE Blank2Lines(Page : CARDINAL);
      VAR i : CARDINAL;
    BEGIN
      FOR i := 0 TO 159 DO Write(Page, CHR(Blank), 2); END;
    END Blank2Lines;

  BEGIN
    MakePoint(p, 0, 0);       GetCursorPoint(SavedCursor, Page0);
    SetCursorPoint(Page0, p); Blank2Lines(Page0);
    SetCursorPoint(Page0, p); Write(Page0, CHR(Blank), 2);
    WriteString(Page0, msg, 2);
    WriteString(Page0, ' [Strike ENTER to go on] ', 2);
    SetCursor(ActivePage);    SetCursorPoint(Page0, SavedCursor);
    RollSplitScreenUp(16);    Terminal.Read(ch);
    RollSplitScreenDown;
  END Pause;

  PROCEDURE GraphicsPause(Page : CARDINAL; msg : ARRAY OF CHAR);
    VAR p : Point; ch : CHAR;
  BEGIN
    MakePoint(p, 8, 8);       SetBiosCursorPoint(Page, p);
    WriteBiosString(msg, 2);
    WriteBiosString(' [Strike ENTER to go on] ', 2);
    Terminal.Read(ch);
  END GraphicsPause;
END Pauses.
```

LISTING 7: POINTLIB.DEF

```
DEFINITION MODULE PointLib;

EXPORT QUALIFIED Point, BumpPointY, BumpPointX, MakePoint;

  TYPE Point = RECORD x, y : INTEGER END;
  PROCEDURE MakePoint (VAR p : Point; x, y : INTEGER);
  PROCEDURE BumpPointY (VAR p : Point);
  PROCEDURE BumpPointX (VAR p : Point);
END PointLib.
```

LISTING 7a: POINTLIB.MOD

```
IMPLEMENTATION MODULE PointLib;


  PROCEDURE MakePoint (VAR p : Point; x1, y1 : INTEGER);
  BEGIN
      p.x := x1;
      p.y := y1;
  END MakePoint;

  PROCEDURE BumpPointY (VAR p : Point);
  BEGIN
    INC(p.y);
  END BumpPointY;

  PROCEDURE BumpPointX (VAR p : Point);
  BEGIN
    INC(p.x);
  END BumpPointX;
END PointLib.
```

LISTING 8: OPCODES.DEF

```
DEFINITION MODULE Opcodes;
  EXPORT QUALIFIED PushAX, PushBX, PushCX, PushDX, PushSI, PushDI,
       PushBP, PushES, PushDS, PushFlags, PopAX, PopBX, PopCX,
       PopDX, PopSI, PopDI, PopBP, PopES, PopDS, PopFlags,
       Iret, Int3, Int;

  CONST
       PushAX  = 050H;      PopAX   = 058H;
       PushBX  = 053H;      PopBX   = 05BH;
       PushCX  = 051H;      PopCX   = 059H;
       PushDX  = 052H;      PopDX   = 05AH;
       PushSI  = 056H;      PopSI   = 05EH;
       PushDI  = 057H;      PopDI   = 05FH;
       PushBP  = 055H;      PopBP   = 05DH;
       PushDS  = 01EH;      PopDS   = 01FH;
       PushES  = 006H;      PopES   = 007H;
       PushFlags = 09CH;    PopFlags = 09DH;
       Iret    = 0CFH;      Int3    = 0CCH;
       Int     = 0CDH;


END Opcodes.
```

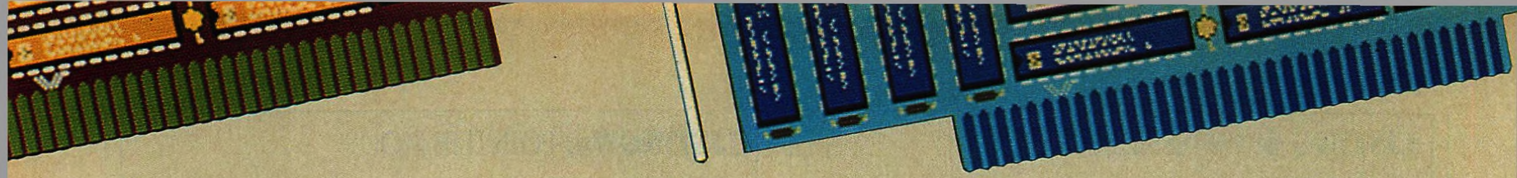
LISTING 8a: OPCODES.MOD

```
IMPLEMENTATION MODULE Opcodes;

END Opcodes.
```

LISTING 9: EGAMAKE.BAT

```
rem
rem compile files in this order to avoid version conflicts
rem
m2 comp  opcodes.def
m2 comp  pointlib.def
m2 comp  lowega.def
m2 comp  pauses.def
m2 comp  drawpoly.def
m2 comp  dottime.def
m2 comp  fontbump.def
m2 comp  lowega.mod
m2 comp  egatest.mod
m2 comp  fontbump.mod
m2 comp  pointlib.mod
m2 comp  opcodes.mod
m2 comp  pauses.mod
m2 comp  dottime.mod
m2 comp  drawpoly.mod
rem
rem Linker requires manual entry of two real-number library file
rem names unless you have renamed one set of the E87, C87, or M87
rem libraries to be your standard set.  If not, add prefix E87, C87,
rem or M87 to library names realc.lnk and reals.lnk & enter manually
rem in response to linker query.   See section 5.7.2 in red manual.
rem
m2 link  egatest
m2 lod2exe egatest
```

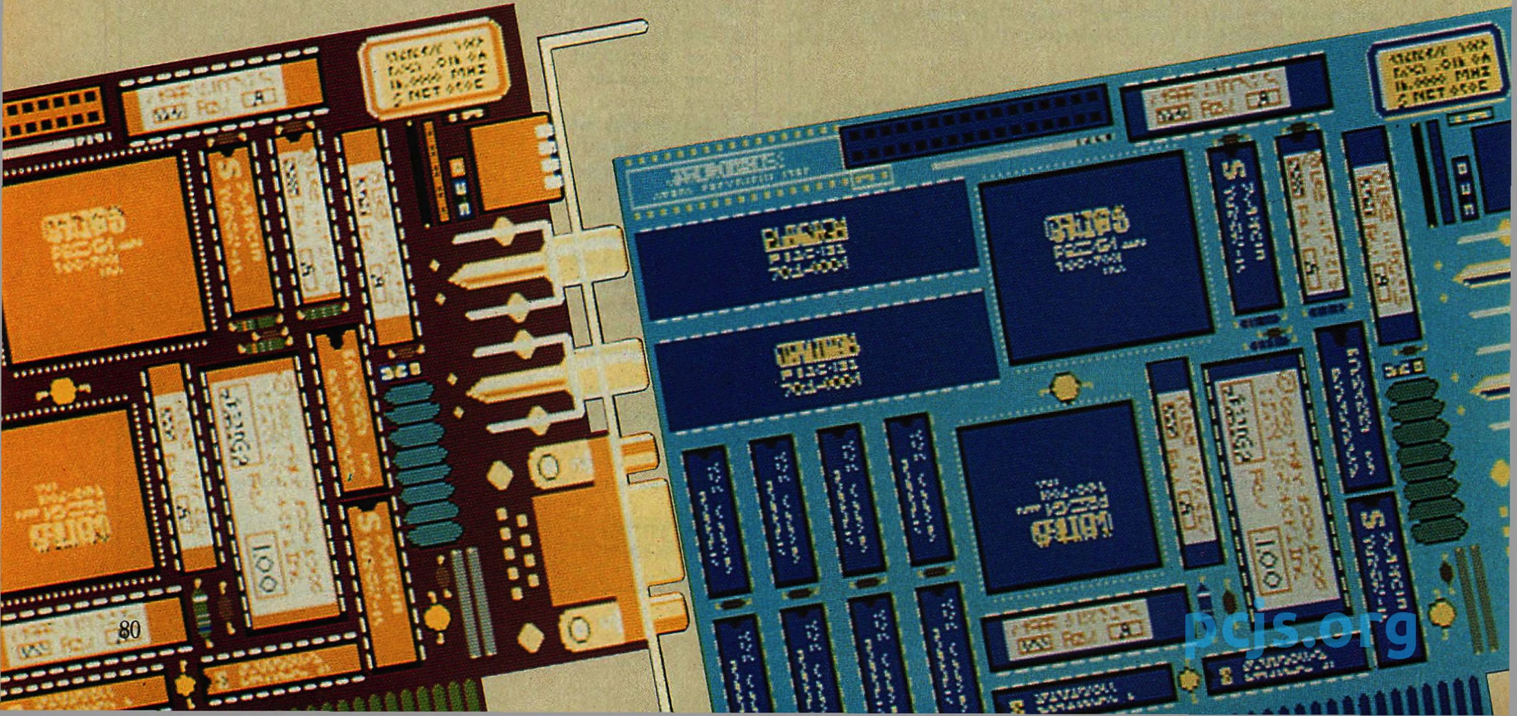


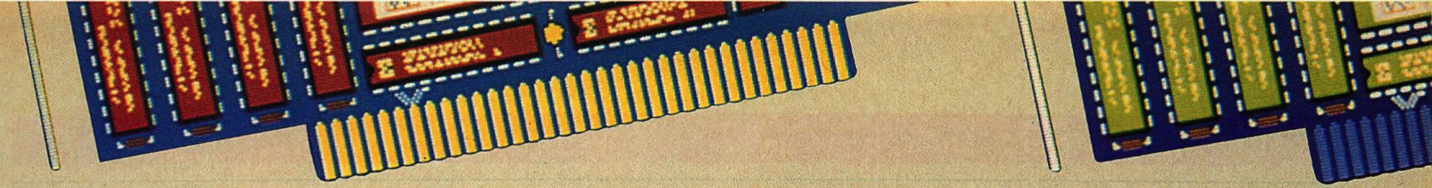
EVALUATING THE EGA

The EGA Spectrum

An emulation EGA chip set paved the way for the introduction of EGA compatibles. Seven bare-bones boards are compared to the IBM model.

JOHN T. COCKERHAM





Imitation, so the saying goes, is the sincerest form of flattery. IBM should be enured to this degree of flattery, by now. It sets de facto standards in nearly every market it enters. Imitating IBM is viewed as the only way to survive and turn a profit.

IBM's Enhanced Graphics Adapter (EGA) is a case in point. Immediately after its introduction, the board was thought to be a failure: no software used its features, and IBM's poor documentation contributed to an underestimation of the power of this new graphics standard. The EGA's nearly $2,000 price tag for a fully configured board and Enhanced Color Display dissuaded many from acquiring this technology. Nonetheless, several manufacturers sensed an opening with the EGA by, if nothing else, undercutting IBM's price. They set their talents to the task of cloning the EGA, and as will be seen in this article and the continuation next month, at least 19 EGA-imitation boards have made it to market.

At first, few thought that the EGA could be duplicated (see "Graphic Enhancement," Thomas V. Hoffmann, April 1985, p. 58). The EGA had many features that, on the surface, seemed difficult to copy. IBM had invested a fair amount in custom VLSI hardware, and the accompanying documentation contained only tantalizing, fleeting glimpses of how the EGA operated.

The turning point came when Chips and Technologies finally built a compatible EGA chip set. C&T openly states that it reverse-engineered the EGA by removing the silicon chips from their DIP packages and making photographic enlargements of the circuits, then working backwards from the photos to logic diagrams. C&T patterned its own copies with a few changes—all perfectly legal before the Silicon Copyright Act of 1984. One penalty for such slavish copying is that all of IBM's bugs come as part of the package. Despite the bugs, the C&T chip set gave many board manufacturers exactly what they were looking for—a quick entry into the EGA market.

In this review of the EGA compatibles, attention is focused on the bare-bones EGA boards: American Mitac's MEGA; AST's 3G Model 1; HR-640E from Basic Time; the Spectra EGA card from Genoa; EGAds! from PCs Limited; STB's EGA Plus; and Tecmar's EGA Master. The features and problems of the basic EGA boards are shown in table 1. Next month's article will center on the advanced boards that offer emulation of other adapters, such as the IBM Monochrome Display and Printer Adapter, IBM Color Graphics Adapter (CGA), and Hercules Graphics Card.

All of the EGA boards underwent a lengthy series of tests directed at the three different functional levels of an EGA: chip, board, and BIOS. The philosophy of testing was simple: exercise as many EGA functions as possible to see where a given board might fail. No single software product exercises all of the functions of the EGA. Many functions, in

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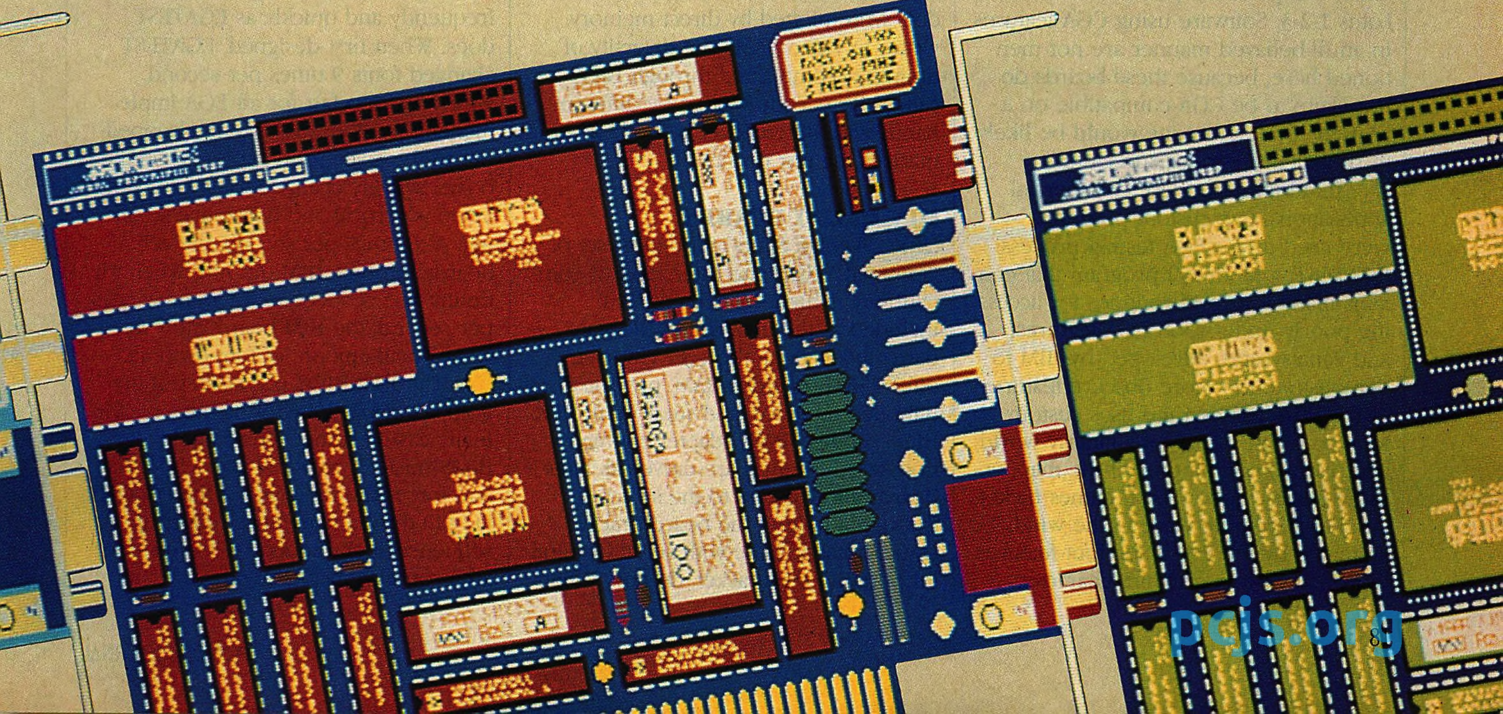

TABLE 1: *EGA Board Features*

	IBM	AMERICAN MITAC	AST	BASIC TIME	GENOA	PCs LIMITED	STB	TECMAR
Price	$982	$220	$500	$349	$595	$269	$495	$395
Model	EGA	MEGA	3G Model 1	HR-640E	Spectra	EGAds!	EGA Plus	EGA Master
Size	Full	Full	Full	Full	Full	Full	Full	Full
BIOS revision	—	1.1	1.22	1.1	1.10	—	1.12	1.22
Revision date	9/13/84	4/6/86	—	—	—	4/15/86	—	—
Video RAM (KB)	64/256	256	256	256	256	256	256	256
Feature connector	●	●	●	●	●	●	●	●
RCA jacks	●	●	●	●	○	●	○	●
Light-pen connector	●	●	●	●	●	●	●	●
Parallel port	○	●	●	○	●	○	●	○
Serial port	○	○	○	○	○	○	○	●
Clock	○	○	○	○	●[a]	○	●[b]	○
ROM disable	○	○	○	○	○	○	○	●
Diagnostic software	●	○	●	○	○	○	○	○
DIP switches through bracket	●	●	●	●	○	●	○	●
PC vertical interrupt correct	●	●	●	●	●	●	●	●
Soft boot correct	○	●	●	○	○	○	●	●
BIOS bugs	—	R, S, T	—	—	A	—	—	—

● = *Yes* ○ = *No* A = *Alt print screen* R = *Cursor setting* S = *Save area* T = *Text not painted in graphics modes* [a] *Extra-cost option ($29.95)* [b] *Extra-cost option ($29.95)*

None of these boards claims CGA emulation, so it must be assumed that ill-behaved CGA software will not run correctly. Interpretation of the BIOS flag controlling warm-boot performance is a BIOS issue and could be corrected through a BIOS update.

fact, are so poorly documented by IBM that software developers are still unaware of them (graphics blinking being the most notable example).

A suite of commercially available applications claiming EGA support was run on every board. All the boards ran all EGA-specific features of the programs, which included Microsoft Windows, Windows Write, Microsoft Word 3.0, Dr. Halo from Media Cybernetics, STSC APL Plus, Graphics Software Systems' Computer Graphics Interface, and Lotus 1-2-3. Software using CGA features in an ill-behaved manner are not mentioned here, because these boards do *not* claim to be CGA compatible on a register level, and none would be likely to run such programs successfully.

In addition to these commercial applications, two custom programs were used in the EGA testing process: EGATEST, a Modula-2 program that contains many low-level routines for accessing poorly understood EGA features; and FantasyLand, developed by IBM to demonstrate the more obscure features of the EGA. FantasyLand uses custom fonts to create a map of a fantasy world and pans through a tour of the map, entirely in text mode. Torch flames flicker and fields of grain wave in the wind, animated by the EGA's soft-font feature, by which custom graphics character fonts are cycled several times per second. (Detailed descriptions of these two programs are in the preceding article, "The EGA Standard," p. 48.)

The success of all boards in running FantasyLand and EGATEST is a testament to the quality of C&T's EGA emulation. Remarkably, the only board failing EGATEST's simultaneous pan and font cycling was IBM's original EGA. The identical C&T hardware at the core of each board also accounts for the consistent timings of the dot-plot test when dots were plotted by direct memory writes to video RAM. The diversity of timings accomplished through BIOS calls reflects code written by different hands with different tools. Table 2 summarizes the test results.

MINIMALIST BOARDS

Little diversity exists among this set of "minimal" EGAs and their level of compatibility is high. All (except IBM, included as the measure of the standard) incorporate the C&T chip set, offer 256KB of video RAM, provide a light-pen interface, and support all IBM BIOS modes. IBM's adapter configuration switch settings are universal. Most boards allow access to the switches through a hole in the board bracket; some, notably those with serial or parallel ports on the bracket, do not. A few control additional features with a DIP block of more than four switches.

IBM. The IBM board comes initially configured with 64KB on 16K-by-4-bit devices. An optional daughtercard expands the video RAM to a full 256KB. When so expanded, each video plane is made up of 8 of these chips for a total of 32 on a fully loaded board. On newer boards, 8 chips total implement 256KB of video RAM more compactly.

The IBM EGA has an obscure timing bug when accessing the font RAM as frequently and quickly as EGATEST does. When first designed, EGATEST changed fonts 9 times per second, which was too fast for all EGA implementations. Portions of fonts dropped out to the background color when the board actively changed fonts with simultaneous vertical and horizontal scrolling. At 6 times per second all C&T boards ran fine; IBM did not. When the timing was reduced to 4.5 font changes per second, the IBM board still had some small amount of font dropout.

The IBM BIOS is considered the gold standard. Some of its bugs are virtually cast in stone. For example, the BIOS misinterprets the warm boot flag and forces the PC (but not the PC/XT or PC/AT) through an entire power-up sequence at any reboot. Also, the save area routines inconsistently save the

TABLE 2: *EGA Board Test Results*

	IBM	AMERICAN MITAC	AST	BASIC TIME	GENOA	PCs LIMITED	STB	TECMAR
EGATEST[a]								
Scroll	pass	pass	pass	pass	pass	pass	pass	pass
Pan	pass	pass	pass	pass	pass	pass	pass	pass
Scroll/pan/cycle font	fail	pass	pass	pass	pass	pass	pass	pass
BIOS dot plot tests[b]								
DMA								
INLINE code	17.9	17.9	17.9	17.9	17.9	17.9	17.9	17.9
Subprogram	20.6	20.6	20.6	20.6	20.6	20.6	20.6	20.6
BIOS	34.8	38.5	33.5	32.0	31.0	31.4	27.4	33.5

[a] Scroll *indicates vertical soft scrolling.* Pan *indicates horizontal soft scrolling. The third test performed simultaneous scrolling and panning while cycling through fonts at 4.5 times per second.*

[b] *Timing results are given in seconds for 65,000 iterations of a dot plot in mode 16. The test machine was an IBM PC with 640KB of RAM.*

The results for dot plotting reflect the near-identical electrical structure of all boards with the C&T chip set. The pass/fail tests were for EGA-specific features; these boards would fail tests of compatibility with IBM's CGA and monochrome adapter.

overscan color in two different offsets within the save area, and the cursor routines are faulty.

IBM packages a new copy of its diagnostics with the EGA. The board's performance on the dot timing test ranks near the bottom of all the boards tested, at 34.8 seconds. Furthermore, IBM provides only a 90-day guarantee.

IBM's superb documentation is worth the price. The IBM EGA technical reference, while containing some now-legendary errors, is still the only manual to consult for any EGA compatible.

American Mitac. The EGA entry from American Mitac Corporation is the Mitac Enhanced Graphics Adapter (MEGA). Its 256KB of video RAM and the C&T chip set are socketed. The board reviewed had a small resistor-capacitor circuit patched on the back, apparently placed there to correct the known timing bug in the first batches of the C&T chip set. The standard jumpers are on the board: monitor changing and I/O readdressing. The ROM BIOS is not disabled if the board is readdressed. The additional jumpers control 64KB operation and I/O delay. Changing this last jumper had no apparent effect.

The MEGA BIOS, written by Quake Computer, is dated 4/6/86. An earlier version contained several bugs that prevented switching between the MEGA and a coresident IBM monochrome adapter via DOS MODE. The tested BIOS release corrected this error, but some faulty BIOS versions have already been shipped. The sans serif font included with this BIOS is clean but harsher on the eyes than standard fonts.

In normal BIOS modes, the Mitac cursor blinks a single horizontal scan line rather than the double line of the other cards. This is unusual, because the CRTC cursor parameters for enhanced mode 3 on the MEGA specify that the cursor run from CGA lines 7 and 8, the same as for all the other boards. Hence, the cursor emulation routines are incorrect. The graphics character write routines are also incorrect, painting characters in white rather than the requested color.

Mitac includes a parallel port, but the connector must be mounted in a spare slot. The port recognizes I/O addresses 3BCH, 3BDH, and 3BEH, which are the same as the printer port on the monochrome adapter. A jumper deselects the port if desired; it cannot be mapped to other I/O addresses.

The tersely written documentation borders on inadequate. It contains six pages of tables and two pages of installation instructions. The MEGA board comes with a six-month warranty.

The BIOS dot timing test scored 38.5 seconds, the slowest performance in this group. All other board tests were passed with ease.

AST Research. AST calls its full-length EGA board the 3G Model 1. It comes fully configured with 256KB of video memory. Interlink Business Network wrote the BIOS, version 1.22, undated. AST uses all of the IBM standard fonts.

The configuration switches, which are mounted behind a hole through the adapter bracket, can be accessed without removing the board from the system. The jumpers controlling the monitor type are located behind the monitor connector; this means that the board has to be removed to change monitors.

The I/O jumper block changes the adapter's I/O addresses, but the ROM cannot be disabled. This requires removing the ROM BIOS chip on a second EGA (or replacing it with a ROM version of a BIOS ORGed somewhere other than C0000H) to operate two AST EGA boards in a single system.

The rest of the jumpers are for the optional parallel port. AST solders the video RAM chips and two of the four video controller chips onto the board.

AST's well-written manual is very complete in directing the user step-by-step through installation and configuration. A map of the board's layout helps locate the numerous jumpers. The documentation of the parallel port's set-up and operation is adequate. No technical information for programming the adapter is given, however.

AST provides a set of diagnostics on diskette that demonstrate standard features. The manual includes a description of the diagnostics and which screens are displayed during their operation. Like most AST products, the 3G Model 1 has a two-year guarantee.

The board passed all of the tests without any difficulty. Its performance on the BIOS timing tests was below average at 33.5 seconds.

Basic Time. Basic Time, which is best known for the products it markets through the U.S. distributing arm Qubié, has produced an EGA card called the HR-640E. The full-length display card has 256KB of video RAM and a parallel printer port. Because of the parallel connector, the RCA phono plugs and feature connector are absent, but are available as an option. The board comes configured from the factory for enhanced color operation. The C&T components and the video RAM are socketed, facilitating repairs.

The configuration switches are on the upper center margin of the card, forcing removal of the system cover to change monitors. The I/O readdressing

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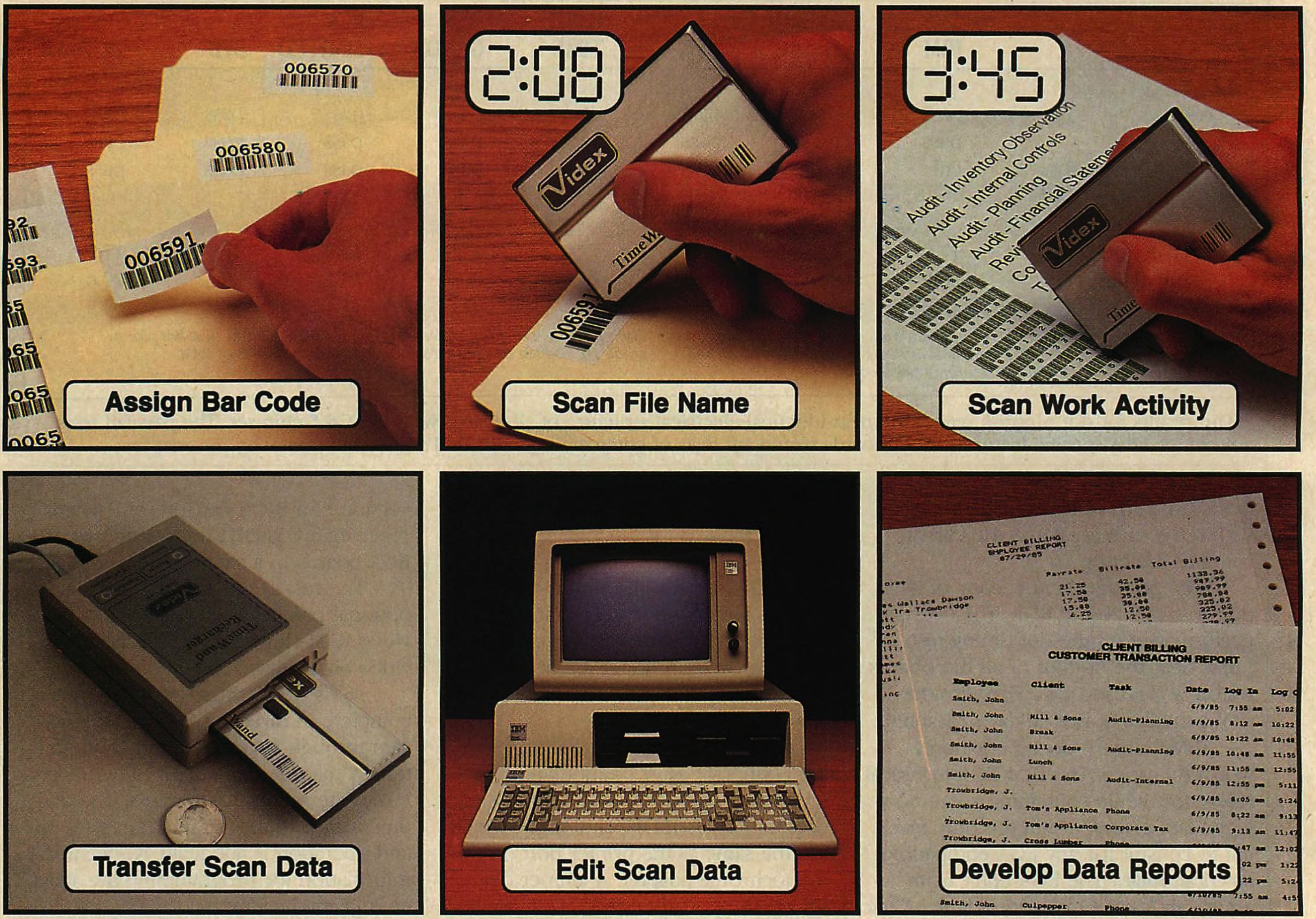

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jumper does not disable the ROM. The parallel port must be configured as either LPT1 or LPT2; and, unlike some of the other parallel ports, it cannot automatically detect the presence of IBM's monochrome parallel port and configure itself as LPT2.

The typewritten manual for the HR-640E is one of the better pieces of documentation among this group of boards. In very clear and concise language the user is guided through installation of the HR-640E. The description of the jumper positions would greatly benefit from a diagram of the board. The major shortcoming of the manual is the description of the parallel port setup, which leaves the user uncertain as to where the parallel port is configured.

With each HR-640E, Basic Time ships a flashy demonstration of the EGA's capabilities with a set of graphics tools from Connell Scientific Graphics. Basic Time offers a one-year guarantee.

The HR-640E passed all the tests to which it was submitted. The BIOS version 1.1, written by Basic Time, contained only one error: the misinterpretation of the warm reboot flag. Consequently, warm reboots take a long time on the PC. The standard font for the HR-640E was similar to IBM's. The board scored below average (32.0 seconds) on the dot timing competition.

Genoa. The full-length Spectra EGA from Genoa is equipped with 256KB of video RAM and a parallel printer port. Genoa gave up the RCA video connectors on the board bracket to make room for the parallel cable connection. The C&T 82C432 timing A-sequencer and the ROM BIOS are socketed. The video RAM chips and the attribute controller are surface-mounted to the board. Any breakdowns, therefore, necessitate replacing the entire board.

A six-position DIP switch bank controls the printer port I/O address and the board configuration. Switches 1 through 4 configure the board at power up; switches 5 and 6 establish the printer port address. The switch block is located on the upper margin of the card near the board bracket but is not accessible through the bracket.

Two jumpers are designated in the manual: JP2 controls the monitor type, and JP1 reassigns the Spectra's I/O address, although it does not disable the board's ROM.

The Spectra EGA BIOS was written by Genoa and carries no date. The version reviewed is 1.1. The BIOS has some serious problems. EGATEST's alternate print screen test, when in 43-by-80 character mode, prints the screen literally forever—it filled a 64KB print buffer before being stopped by a reboot. A replacement version of the BIOS (1.2) proved to be worse. The filling and splitting tests did not work, nor did the split screen.

Genoa packages the Spectra EGA with three pieces of software: a mode-switching program (EGASM), a reconfiguring program (EGASW), and a PC (not EGA) ROM dating program. Because the BIOS polls the switches only at power-up, EGASW is required to modify the EGA information byte containing the switch settings and the feature bits. Unless modified again by EGASW, these settings remain in force until power-down. The ROM dating program is actually a customer-service assistance tool to enable a nontechnical user to determine whether a PC contains the pre-ROM scan BIOS, without which the EGA cannot be used.

The EGA Master is the only board designed to support two EGAs in a single system. The BIOS support requires that both be Tecmar boards.

The concise manual that accompanies the Spectra board describes installation and set-up clearly. The switch settings are easy enough to understand.

Spectra scored an acceptable 31.0 seconds on the BIOS timing test. Genoa offers a one-year guarantee.

PCs Limited. The PCs Limited EGA sells under the name EGAds!. This full-length board has 256KB of video RAM. No additional ports or other hardware features are available. The board is sold with PCs Limited's new 286-12 12-MHz AT compatible, so it is assumed to run at speeds up to 12 MHz.

The board has two jumpers that are easily located without the documentation. One controls the monitor type, and the other, unexplained in the documentation, probably remaps the board's I/O addresses. However, moving the I/O addresses does not disable the ROM BIOS, so it must be removed if two EGA boards are to be installed in the same system. The eight 64K-by-4 video RAM chips and all of the video controller chips are socketed.

Quintessential Computer Consultants wrote the BIOS, dated 4/15/86. It has a slight flaw: unrecognized video function calls are not passed on to the revectored video interrupt at INT 42H. Requests for unrecognized functions thus return harmlessly (but uselessly) to the calling logic. The BIOS incorrectly recognizes the warm reboot flag, slowing down every reboot.

More problematic than the BIOS is the font, a standard serif with a few changes from the IBM font. The EGAds! font places the small bullet character (0FAH) one pixel line above a period, so it is easily confused with a period.

The brief 14-page manual provided by PCs Limited adequately describes the installation of the board. Configuration tables comprise the bulk of the documentation. A BASIC program describes the interface to the ROM BIOS.

PCs Limited offers no software with the board. The EGAds! passed all tests including all of FantasyLand. The BIOS dot timing is an average 31.4 seconds.

STB. The full-length EGA Plus from STB implements all of the EGA functions with 256KB of video RAM. The chips are socketed. The board reviewed had one jumper wire on its circuit side.

The EGA Plus has a parallel port on the board bracket. To fit the parallel port connector on the bracket, the RCA plugs and access to the mode switches through the bracket had to be given up. Eight DIP switches are at the upper margin toward the rear of the card. The first four control the EGA mode. Switches 5 and 6 specify the printer port address. Switch 7 determines 64KB versus 256KB video RAM modes. Switch 8 is undocumented. When the cover is off, the switches are readily accessed.

The board includes a socket for a clock chip but not its battery, which must be mounted off-board with the power leads connected to a two-pin header. Boards without clocks are shipped with a shorting wire in the clock chip socket. This shorting wire can potentially reset any other clock that shares the same I/O address, as happened with the clock in the test PC. The clock and the parallel port must be enabled or disabled together; it is not possible to have one without the other.

STB and Award Software share the BIOS copyright. The current revision level is 1.12 and undated. A previous BIOS version could not switch between the IBM monochrome adapter and the EGA Plus using the DOS MODE command when the adapters were coresident. A more serious BIOS bug was removed more recently: when specifying a save area and changing a palette register (via function AH = 10H), the BIOS

does not post the new value in the user's save area. Instead the BIOS confuses the user's code segment for the data segment of the save area pointer, thus posting the new palette value in the middle of the user's code and potentially causing a crash. Although both bugs have been fixed, many of the problem boards exist in the field; current owners should check their BIOS revision level and demand an update for anything prior to 1.12.

The documentation guides the user through installation. Jumper positions are indicated on a map of the unit and with individual diagrams.

STB includes a copy of PC Accelerator software with EGA Plus. This set of utility routines loads as a DOS device driver, creating RAM disks and print buffers. Also provided are graphics drivers for Lotus 1-2-3 and Symphony.

STB's board led all others in dot timing performance with 27.4 seconds. The board has a two-year warranty.

Tecmar. Tecmar's EGA Master comes configured with 256KB of video RAM. The EGA chips are surface mounted, but the BIOS and a PAL chip are socketed to allow easy firmware updates. Two jumper wires are found on the board's trace side. All of the board configuration switches, including monitor selection, are accessible through the board bracket. The system unit cover does not have to be removed when attaching a new monitor, as with STB.

The EGA Master is the only reviewed board designed to support two EGAs in one system. The BIOS support requires that both be Tecmar boards. Dual-board support is handled by the PALs rather than the BIOS. Initially, one board is mapped at 3x5H and the other at 2x5H by way of a jumper on the board. Only one board can be actively programmed at a time; the one mapped at 3x5H is active by default. The PALs on the active board monitor the feature connector output register. When the active board writes to that register, the PALs on both boards temporarily map both boards' feature connector registers to the same I/O address. A second I/O output to that address stores a value to bit 3 on the feature connector registers simultaneously. The board in which a high bit in bit 3 matches the setting of the jumper becomes the currently active board. Both boards can thus be accessed through the same BIOS—and two copies of the ROM BIOS can exist at the same memory address.

The reviewed board included the optional serial port. The 25-pin serial connector must be mounted in a spare board bracket slot, however. The I/O addresses for the serial port are designated through switches 1, 2, and 3 of switch block 2, which is not accessible through the bracket.

Like the AST 3G Model 1, EGA Master uses the Interlink Business Network BIOS, which passed all tests. As expected, the BIOS timings are identical to AST's. PC warm reboots do not cause the delay that IBM and other boards do.

For this review, Tecmar provided an unfinished version of its documentation. Step-by-step instructions direct the installation of the EGA Master. No technical discussion of the board is included in the documentation; information about dual-board operation was obtained from Tecmar's engineers. The guarantee lasts for one year.

COMMODITY ITEMS

The basic enhanced graphics board is now a standard implementation with a standard BIOS and chip set. Low-end EGA boards are becoming commodity items. None of these boards claims complete compatibility with IBM's earlier display adapters or the Hercules adapter. The C&T chip set does little to improve on IBM's EGA, which is incompatible with the monochrome adapter and CGA except on a BIOS level.

BIOS quality and performance vary widely, but this should be balanced against the fact that performance-sensitive code is rarely written through the BIOS. Most video output, in particular, is done by writing directly into video RAM, where the timings are dictated more by the C&T hardware than by the BIOS software and are more consistent across the field. A slow but correct BIOS is much better than a screamer with a tendency to drive off cliffs.

Having ports or a clock on a board is helpful, but these features are often obtained at the cost of accessing the EGA configuration switches through the bracket, as in the Genoa and STB products. If the adapter configuration must be changed more than rarely, easy access to switches is important.

In a commodity market, perhaps the best product is the one about which there is the least to say. Tecmar's EGA Master was the closest to bug-free of any of the boards tested and ran every EGA-specific application without problems. It is the only board with a serial port option and yet still allows switch access through the board bracket. It is also the only board that reasonably addresses a need for two EGA boards in one system without requiring the user to write a second BIOS ORGed at a different memory address. These features, along with Tecmar's long tenure in the graphics board business, make the EGA Master stand out in an otherwise undistinguished field.

John T. Cockerham, M.D., is a pediatric cardiologist at The Children's Hospital and is on the faculty of Harvard Medical School.

EGA (256KB): $982
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CIRCLE 350 ON READER SERVICE CARD

HR-640E: $349
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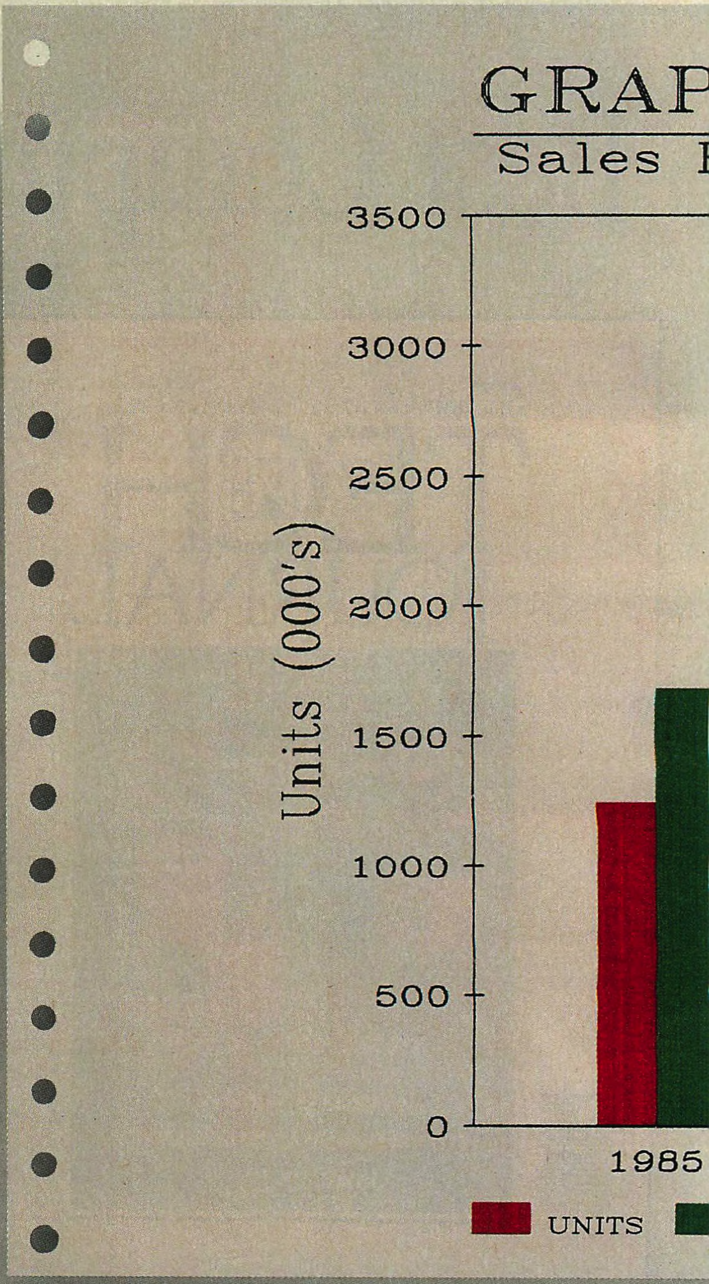

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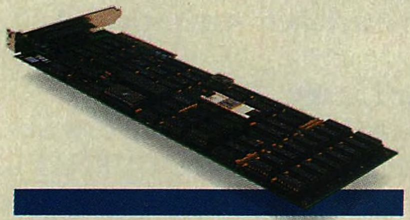

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The Ascent of DOS

The evolution of DOS has mirrored the development of IBM mass storage technology, yet a few compatibility difficulties between 2.x and 3.x versions can cause programming problems.

TED MIRECKI

PC-DOS is five years old. By computer industry standards, especially microcomputer standards, that is an eternity. Although DOS may seem like an old-timer, this operating system has not been standing still. During these five years no fewer than seven versions have been introduced, with a new one appearing, on the average, every nine months. The latest version of DOS is as different from the first as an 8-MHz PC/AT with a 30MB hard disk is from the original PC with its single-sided diskette drives. Table 1 shows the versions, their introduction dates (taken from the time stamps of the system files), and the new hardware each version was introduced to support, usually a new type of disk drive.

The history of DOS divides into two distinct phases. The first was the era of versions 1.0 and 1.1. These early versions were developed from an operating system that Microsoft had purchased from Seattle Computer Products, which in turn based it on the then-dominant CP/M operating system for 8-bit 8080 and Z80 microprocessors. In effect, early DOS was a superset of CP/M for 8086/88 machines.

Although Microsoft does sell DOS to manufacturers of compatibles through OEM agreements under the name of MS-DOS, current PC compatibles are able to run IBM's PC-DOS right out of the box. This makes a "generic" MS-DOS version much less important today, because PC-DOS is unbundled and may be purchased by anyone.

The second (and current) phase of DOS began with the introduction of version 2.0. This was essentially a brand new operating system, developed internally by Microsoft and designed more or less as a single-user subset of UNIX. Significant new features were support for hard disks, tree-structured directories, I/O redirection and piping, installable device drivers, and a more convenient file I/O interface between applications and the operating system.

Given the fundamental differences introduced by DOS 2.0, its compatibility with the earlier versions was a minor miracle. Despite the fact that all subsequent versions have maintained compatibility, DOS 1.x is considered dead and buried; neither Microsoft nor any vendor of MS-DOS systems sells or supports it any longer. Today it is perfectly acceptable for commercial programs to ignore DOS 1.x, and, indeed, most useful programs currently require version 2.0 or later to execute.

After the revolutionary changes of DOS 2.0, subsequent updates were more evolutionary in character. Version 2.1 had internal modifications only, made necessary by the different characteristics of the half-height drives introduced with PC*jr* and the Portable PC. This was the only version to date that did not initiate any new commands.

Version 3.0 was, in at least one respect, disappointing. Although it was introduced with the AT, the new version did not support the extended memory addressing capabilities of the 80286. DOS 3.0 was a significant step in the evolution of an operating system for the 8088, but it was not the 80286-based system required by the AT. Apart from the support for the AT's 1.2MB floppy diskette, the major externally obvious improvement was the ability to specify a subdirectory as a command name prefix, a capability that was sorely missed in previous versions.

One undocumented feature of DOS 3.0 and subsequent versions is that prefixing a command with a path limits the search for the command file to that one directory. For example, typing A:\PROG causes DOS to look for the PROG file only in the root directory of drive A:. If the file is not found there,

ILLUSTRATION • ANDY LEVINE


DOS 3.2

an error message is issued. On the other hand, typing A:PROG causes DOS to search the current directory on drive A:. If PROG is not found there, then the directories listed in the DOS path are searched in order.

Internally, DOS 3.0 introduced a significant change in the structure of the file allocation table (FAT). Each FAT entry (corresponding to one cluster on the disk) was represented as a 16-bit rather than a 12-bit number, permitting a maximum 65,536 clusters per disk instead of the previous 4,096. More clusters on a disk means that for a given disk capacity, the clusters can be smaller, and, therefore, disk space can be used more efficiently. A 20MB hard disk, for example, has clusters of 2KB when formatted with DOS 3.x, compared to 8KB clusters under DOS 2.x.

The choice of cluster size involves a trade-off between space efficiency and I/O speed. The smaller the cluster, the more tightly files can be packed onto disk, because file space must be allocated in integral clusters. But the larger the cluster, the more information is reachable for each access of the FAT, thereby increasing I/O speed. With increasing processor speed, it becomes more acceptable to perform the additional processing associated with smaller cluster sizes. On the AT's high-capacity diskettes, clusters are 512 bytes, the smallest possible cluster size. No doubt IBM felt that the primary use of this diskette format would be for backing up the hard disk; it therefore maximized the effective storage capacity at the expense of disk I/O speed.

Other characteristics of DOS 3.0 were covered at length in a previous article ("Irresistible DOS 3.0," Julie Anderson, December 1984, p. 74) and will not be repeated here. However, one other significant fact about 3.0 must be noted: it was the only new version that did not replace its predecessor. The problems caused by the coexistence of versions 2.1 and 3.x are discussed later in this article.

Version 3.1 fulfilled the promise of network support made by 3.0. Even for stand-alone systems, 3.1 introduced improvements that seemed long overdue. The most significant of these was the SUBST command, which assigns a drive letter to any path, allowing access to files in subdirectories from programs that understand only drive IDs, as is the case in DOS 1.x. Had this capability been provided with DOS 2.0, the transition from the earlier version of DOS would have been much less painful. Now, the old ASSIGN command can be consigned to the scrap heap along with EDLIN. SUBST permits reasonable use on a hard-disk system of programs such as WordStar and BASCOM that were not updated to support path names. For users of such applications, the SUBST command alone is well worth making the upgrade to DOS 3.1.

TABLE 1: *PC-DOS Version History*

VERSION	INTRODUCED	MONTHS	REASON
1.0	August 1981	9	IBM PC
1.1	May 1982	10	Double-sided disk drives
2.0	March 1983	7	Fixed-disk drive (PC/XT)
2.1	October 1983	10	Half-height disk drives (PC*jr*, Portable PC)
3.0	August 1984	7	1.2MB floppy diskettes (PC/AT)
3.1	March 1985	9	IBM Network
3.2	December 1985	?	3½-inch diskette drive (PC Convertible)

In all cases but one, updates to DOS have been driven by advances in IBM's mass storage technology. (Among other enhancements, DOS 3.1 supported the IBM Network.) Versions 2.1 and 3.2 are supported concurrently, as DOS 2.1 contains all necessary support for non-networked PCs and PC/XTs using 5¼-inch media.

Another new command introduced by DOS 3.1 was JOIN, which causes an entire drive to be treated as a subdirectory of another drive. One minor annoyance with JOIN is that the subdirectory that becomes the logical equivalent of a specified drive ID is not removed when the join is disabled. In effect, JOIN is the complement to SUBST, a command that treats a subdirectory as a separate drive.

JOIN and SUBST are external commands, implemented as .EXE files. Although their effect continues after they are run, they are not terminate-and-stay-resident programs; evidently, they only modify some internal DOS tables, then disappear from memory. The effect of both may be reversed without rebooting. A more serious shortcoming of both commands is that application programs cannot determine if a drive ID is really a substituted directory or if a directory is really a joined drive. In some cases, the joins and substitutions are not transparent, for example, in low-level programs such as the Norton Utilities. CHKDSK, which also performs processing at a fairly low level, gets around the problem simply by ignoring it; it issues the message "Cannot CHKDSK a joined or substituted drive" and quits. The DOS documentation also warns the user not to issue other commands while a JOIN or SUBST is in effect. These include ASSIGN, BACKUP, DISKCOMP, DISKCOPY, FDISK, FORMAT, LABEL, and RESTORE.

An important feature of DOS 3.1 was its correction of bugs in the BACKUP command of DOS 3.0. In the earlier version, BACKUP would misnumber diskettes whenever a file did not get split over more than one disk, that is, when it just filled up the disk. BACKUP now works correctly (in this case). DOS 3.1 introduced no changes in the programming interface (the interrupts and function calls by which programs access DOS resources).

THE LATEST IN DOS

The latest version of DOS is 3.2, which was introduced with the PC Convertible (IBM's laptop microcomputer). Its major enhancements are support for 3½-inch, 720KB micro floppy-disk drives and for the IBM Token-Ring Network, but several other general improvements are included. The most visible are the REPLACE and XCOPY commands, both of which are enhancements of the venerable COPY command.

In its basic form, REPLACE copies from the current or specified directory only those files that already exist on the target drive. The search on the target drive is normally confined to its current directory, but may be extended to all of its subdirectories. This latter form is especially useful for updating a DOS disk to a new DOS version. After performing a SYS command to copy the hidden DOS files, REPLACE can be used to copy only the external DOS files that already exist on the target drive. This means, for example, that ASSIGN.COM and EDLIN.COM will not be copied if they do not exist in any subdirectory on the target drive, while COMMAND.COM will be copied to every subdirectory that contains the file already.

An optional parameter may be used to direct REPLACE to perform the exact opposite function of its name: to copy only those files that do *not* exist on the target drive. Other options control whether read-only files on the

target are replaced, and whether the system asks for confirmation before replacing or adding each file.

The XCOPY command is a more straightforward extension of COPY, with the capability to copy all of the files in all the subdirectories below a specified point on the source drive. The subdirectory structure from the specified directory of the source drive is duplicated at the target directory. An optional switch forces XCOPY to reproduce on the target drive any empty subdirectories it discovers while traversing source subdirectories. Ordinarily, XCOPY does not create empty subdirectories on the target drive.

XCOPY may be used as an alternative to BACKUP, because it can process the archive attribute of files and copy only those that have changed since the last BACKUP or XCOPY operation. Unlike BACKUP, however, XCOPY does not modify the copies by adding ID headers, nor does it split files over disk boundaries. The copies are usable directly from the backup medium and may be restored with COPY, XCOPY, or REPLACE, but not RESTORE.

An interesting feature of XCOPY is that it reads as many target files as will fit into memory and only then begins writing them. COPY and REPLACE, by contrast, read and write short files one by one and files that are larger than 64KB in chunks of 64KB.

Another new feature of DOS 3.2 is a device driver called DRIVER.SYS. Its main function is to provide support for external 3½-inch drives, but it can handle other types of disk drives. Loading DRIVER.SYS for a given physical drive assigns the next logical drive letter to that drive, permitting references to one drive by two or more letters. For example, on an AT where A: is a 1.2MB drive, B: a 360KB drive, and C: a hard disk, DRIVER.SYS may be used to assign D: to the first drive and E: to the second by including the following lines in the CONFIG.SYS file:

```
DEVICE=DRIVER.SYS /D:0
DEVICE=DRIVER.SYS /D:1
```

The /D represents a command, *not* a drive letter. When performing, for example, a DISKCOPY from A: to D: (after loading DRIVER.SYS as shown above in the first line), the system will prompt for disk changes in the 1.2MB drive, just as DOS now does for A: and B: on systems that have only one floppy-disk drive. Similarly, a single external 3½-inch drive added to a PC/XT or AT may be assigned two drive letters to facilitate copy operations.

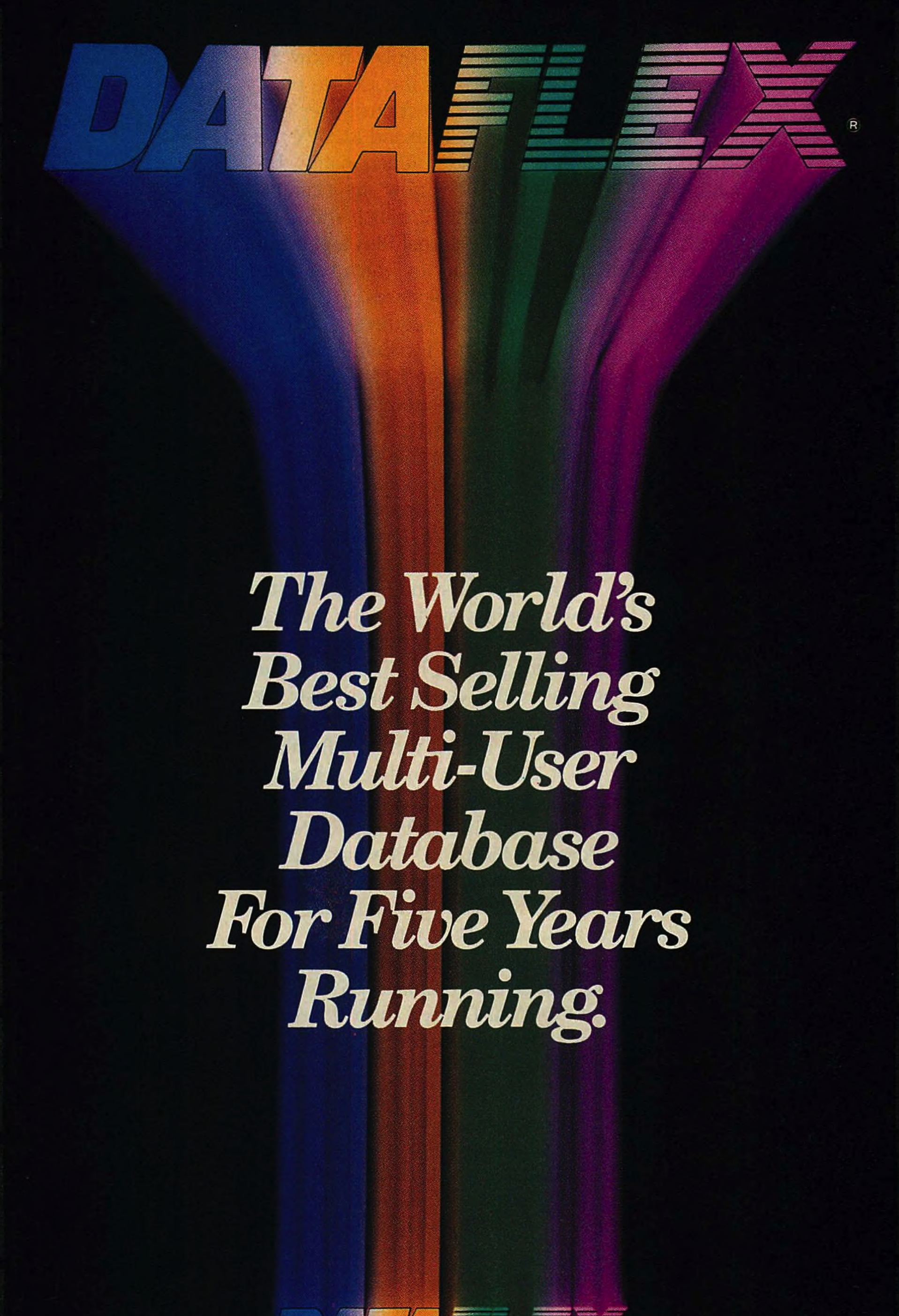
Improvements were made to several other DOS commands. In previous versions, the ATTRIB command could change just the read-only bit; now it also can set or clear the archive bit. This provides better control over the operation of BACKUP and XCOPY. Yet, in spite of its added functionality, the ATTRIB.COM file is now significantly smaller. (See table 2, which shows the growth of the external files and serves as a brief summary of which versions introduced which features.)

FORMAT now requires a drive ID, and will not begin formatting the default drive until an ID is given. As before, the user is asked for confirmation if the requested drive is nonremovable. If a nonremovable disk has a volume label, the user is asked to type it in as additional confirmation. Fortunately, formatting a hard disk inadvertently is becoming more and more difficult.

The new version of FORMAT also shows progress by displaying the track and head numbers. Besides giving a visual indication of how far along the process is, this continuous display has one other significant effect: formatting may be interrupted with Ctrl-Break even if BREAK has not been set on. Ctrl-Break is recognized during any console I/O. With DOS 3.2, FORMAT returns an ERRORLEVEL value, allowing batch files to detect when format operations are interrupted, and branch based on the cause of the interruption.

SHELL, a configuration command that names the command processor, and COMMAND, used to load a second copy of the command processor, now allow a parameter that specifies the size of the DOS environment. This feature was present in some previous DOS versions but was not documented; now it is official and works reliably. However, in DOS 3.2 the size is given in bytes, not in paragraphs as in previous versions. The minimum (and default) environment size is 160 bytes, and the maximum is 32KB. The requested size is only the initial environment allocation; the environment can grow beyond this with sufficient room—that is, if an unallocated memory block is available immediately following the end of the reserved area. The SHELL command can be used to specify extra space for the main DOS environment by loading the COMMAND.COM file from a SHELL statement, along with a parameter specifying the desired amount of environment space in bytes.

Another new configuration command, STACKS, was added to DOS 3.2 at such a late date that it could not be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included in the "Configuring Your System" chapter of the manual. Instead, STACKS is documented in an appendix at the end of the book where many users may miss it on the first reading. This command sets the size of the stack that is used during the servicing of hardware interrupts.

Hardware interrupts are those generated by events outside of a running program: the tick of the system timer, the press of a key on the keyboard, or the receipt of a character at a serial port. In previous versions of DOS, a hardware interrupt transferred control directly from a running program to an interrupt service routine, usually in BIOS, without involving DOS. The interrupt routine used whatever stack was in effect within the interrupted program.

In version 3.2, all of the hardware interrupt vectors are repointed into the DOS kernel in low memory. When an interrupt occurs, DOS gains control, points the stack registers to an area within itself, and then chains through to the original service routine. The STACKS command determines the total size of this area and the number of nested interrupts that can be supported.

The new scheme of handling hardware interrupts through DOS is just one example of the trend towards isolating programs from the hardware. With DOS interposed between an application and BIOS, the application programmer need not be concerned wtih providing stack space for hardware-related events external to the program.

But the question remains, why is it necessary to expand the size of the interrupt stack? The default size can handle nine nested interrupts, and it seems inconceivable that more than this can occur. The interrupt controller used in the PC and AT has eight prioritied channels, and when one interrupt is being serviced, only one of higher priority can interrupt it. (See "Interrupts and the PC," Chris Dunford, November/December 1983, p. 137.) In the worst case, the nesting depth cannot exceed eight. Despite its 15 levels of interrupts, even the AT is limited to eight nested interrupts because it has two cascaded interrupt controllers, each with eight levels. The output of the secondary controller is the third-highest priority (IRQ2) input to the primary one. While a secondary interrupt is being serviced, as many as five primary levels may be nested below it, and only primary levels 0 and 1 may interrupt it. Subsequent interrupts from the secondary controller arrive on the same priority level as the one that is in process

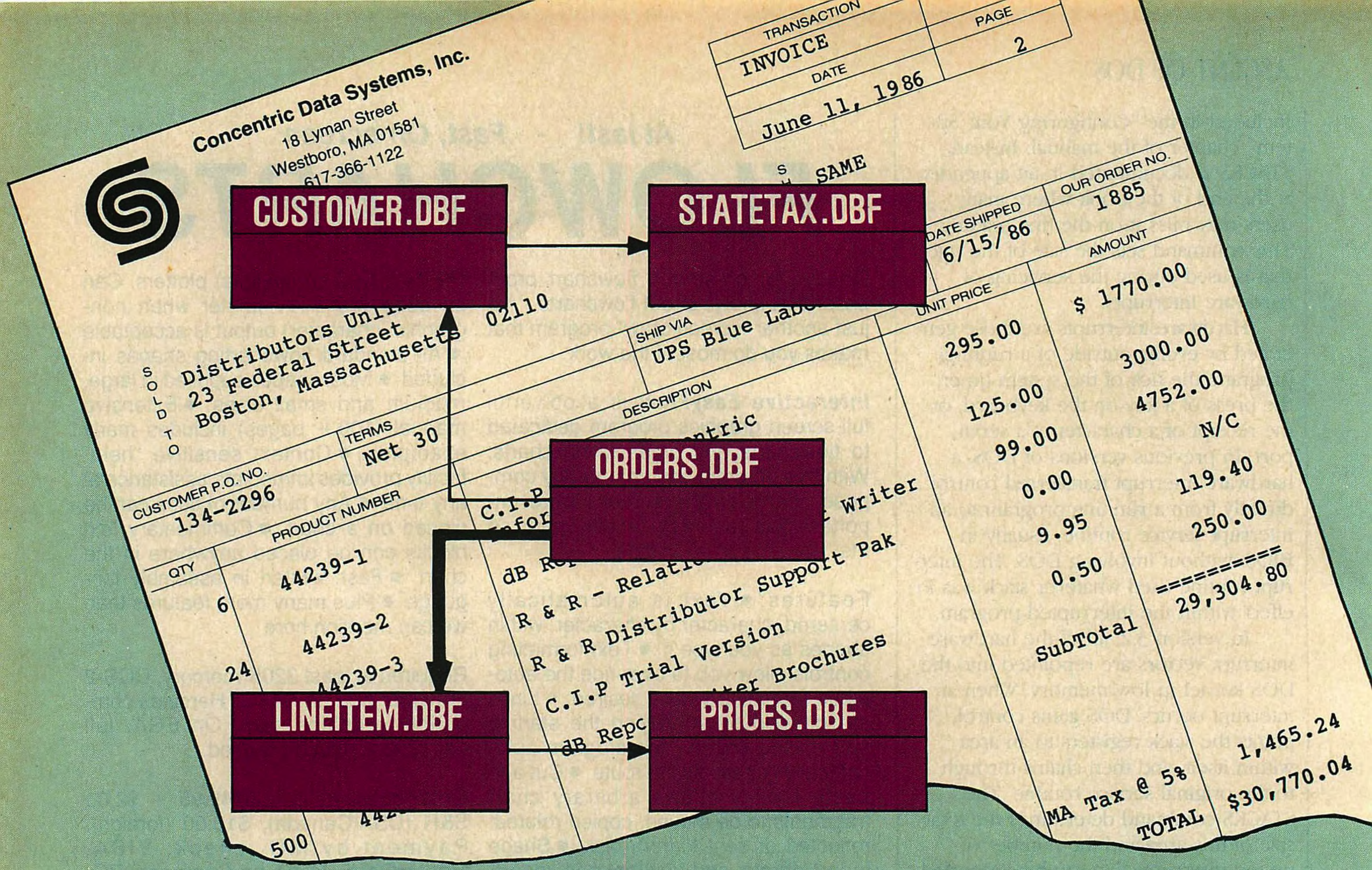

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TABLE 2: *DOS External Utilities*

UTILITY DOS VERSION	2.0	2.1	3.0	3.1	3.2
ANSI.SYS	1,664	1,664	1,641	1,651	1,651
ASSIGN.COM	896	896	988	1,509	1,536
ATTRIB.EXE	—	—	15,123	15,091	8,247
BACKUP.COM	3,687	3,687	5,440	5,577	6,234
BASIC.COM	16,256	16,256	17,024	17,792	19,298
BASICA.COM	25,984	26,112	26,880	27,520	36,396
CHKDSK.COM	6,400	6,400	9,275	9,435	9,832
COMP.COM	2,523	2,534	3,471	3,664	4,184
DEBUG.COM	11,904	11,904	15,237	15,552	15,799
DISKCOMP.COM	2,074	2,188	3,752	4,073	5,792
DISKCOPY.COM	2,444	2,576	4,165	4,329	6,224
DRIVER.SYS	—	—	—	—	1,115
EDLIN.COM	4,608	4,608	7,183	7,261	7,508
EXE2BIN.EXE	1,664	1,664	2,752	2,816	3,063
FDISK.COM	6,177	6,369	8,076	8,173	8,173
FIND.EXE	5,888	5,888	6,363	6,403	6,416
FORMAT.COM	6,016	6,912	9,015	9,398	11,135
GRAFTABL.COM	—	—	1,169	1,169	1,169
GRAPHICS.COM	789	789	3,111	3,111	3,220
JOIN.EXE	—	—	—	15,971	8,955
KEYB??.COM[a]	—	—	10,033	12,051	15,848
LABEL.COM	—	—	1,260	1,826	2,346
LINK.EXE	39,936	39,936	45,970	38,144	39,076
MODE.COM	3,139	3,139	5,194	5,295	6,864
MORE.COM	384	384	320	282	295
PRINT.COM	4,608	4,608	7,811	8,291	8,976
RECOVER.COM	2,304	2,304	4,066	4,050	4,297
REPLACE.EXE	—	—	—	—	11,650
RESTORE.COM	4,003	4,003	5,413	5,410	6,012
SELECT.COM	—	—	2,079	2,084	3,826
SHARE.EXE	—	—	8,544	8,304	8,580
SORT.EXE	1,280	1,408	1,632	1,664	1,911
SUBST.EVE	—	—	—	16,611	9,911
SYS.COM	1,408	1,680	3,629	3,727	4,620
TREE.COM	1,513	1,513	2,473	2,831	3,357
VDISK.SYS	—	—	3,080	3,307	3,307
XCOPY.EXE	—	—	—	—	11,200

— = Feature not yet introduced
[a] Total of five files

Both the number and size of DOS external utilities have grown as PC-DOS has increased in complexity, with the exception of ATTRIB, JOIN, and SUBST. These three utilities have become significantly smaller (by about 7KB each).

TABLE 3: *DOS Primary Files*

PRIMARY FILE	2.0	2.1	3.0	3.1	3.2
IBMBIO.COM	4,608	4,736	8,964	9,564	16,369
IBMDOS.COM	17,152	17,024	27,920	27,760	28,477
COMMAND.COM	17,664	17,792	22,042	23,210	23,791
Total on disk	39,424	39,552	58,926	60,534	68,637
Resident size	24,672	24,672	36,896	36,896	46,304
Transient size	13,312	13,328	17,552	18,288	18,464
Total in memory	37,984	38,000	54,448	55,184	64,768

DOS 3.2 requires nearly twice the RAM and disk space required by DOS 2.1. Most of the growth between DOS 3.1 and DOS 3.2 occurs within IBMBIO.COM, in support of the new IOCTL commands and the 3½-inch diskette devices.

and will not be recognized until the current interrupt is completed.

The only way that more than nine nested interrupts can occur is if interrupt service routines are recursive, that is, call themselves. According to Microsoft, this is a possibility in routines that support the token-ring network. In normal use, however, the default size is more than sufficient.

EXPANDED IOCTL

In the area of programming, DOS 3.2 provides new capabilities in only one area, that is the DOS IOCTL functions (AH=44H) of INT 21H. The IOCTL functions are numerous and beyond the scope of this article. Only a summary description will be presented here.

The new IOCTL subfunctions make available at the DOS level many of the low-level disk I/O functions performed by INT 13H of BIOS. In the previous DOS version, subfunctions 0 through 0BH were defined. Three new subfunctions (all with AH=44H) are defined in DOS 3.2: AL=0DH (generic IOCTL request), AL=0EH (get logical drive), and AL=0FH (set logical drive). Subfunction 0CH is unaccounted for and presumably reserved for future use.

The structure of the new IOCTL calls is somewhat strange. The generic IOCTL subfunction has six sub-subfunctions, but these are coded one level *lower* than expected in that the generic subfunction has been divided into major and minor codes. Thus, to perform one of these subfunctions, the register contents are as follows:

AH=44H IOCTL function of INT 21H
AL=0DH Generic IOCTL request subfunction
CH=08H Major category code
CL= Function within category (minor code)

At present, only one major category code is defined (CH=08H), but the overall organization of IOCTL indicates that more complicated command structures can be expected in future DOS versions. The functions within this major category are as follows:

CL=40H Set device parameters
CL=60H Get device parameters
CL=41H Write track
CL=61H Read track
CL=42H Format and verify track
CL=62H Verify track

Set device parameters has two purposes. First, for drives that support more than one type of media (such as the high-capacity AT drives that handle 1.2MB and 360KB diskettes), this function can set the default BPB (BIOS parameter block) that will be used in ini-

tial I/O attempts. Second, this function may set a table of sector IDs and sizes for subsequent format functions.

The next function, **get device parameters**, returns a table of drive characteristics, including the total number of cylinders (tracks) on the drive and the BPB. The BPB is recorded in the boot sector of any disk formatted with DOS 2.0 or later, but previously it was accessible only by means of an absolute read of logical sector zero. Making this information available through DOS isolates applications from dealing too intimately with the hardware, leaving such low-level details within the operating system where they belong.

The **read track** and **write track** functions perform I/O on one or more sectors. Unlike INT 25H and 26H, these functions cannot read or write across track boundaries. The place on the disk where the data transfer is to start is identified by head number, track number, and sector within track. These parameters are essentially the same as for the read and write functions of INT 13H, with one important difference: for IOCTL, the sectors are numbered from 0, whereas for INT 13H, they are numbered from 1. Thus, for a 360KB drive with nine sectors per track, IOCTL considers the sectors to be numbered 0 through 8, while INT 13H operates on them as 1 through 9. The latter is preferable because it follows the way sector IDs are actually recorded on the disk.

The **format and verify track** function operates on one track at a time. Each sector on the track may be a different size. The IDs and sizes for each sector in the track are taken from a track layout table established by a previous **set device parameters**. The verify function of **format and verify track** operates *before* the format takes place; it actually checks to see if the requested formatting parameters produces a legal track. If the requested track is legal the format takes place, otherwise an error message is returned. **Verify track** is similar in that it checks for a legal track, but instead of going ahead with the format, it simply returns a "go/no" message to the calling logic. This is not the same as the INT 13H verify function that checks to see if the CRC code for a given sector is correct for the data.

DOS 3.2's new IOCTL subfunction, **get logical drive**, determines if a physical drive has more than one drive letter assigned to it, and if so, which letter was last used to reference that drive. The complementary subfunction, **set logical drive**, switches a physical drive to a specified drive ID, so that the next I/O request to that device does not issue a message to swap diskettes. Using these two subfunctions, an application can control its own disk swapping messages, instead of relying on DOS.

To use these new IOCTL subfunctions, device drivers must be designed to support the corresponding new command codes: 19H for **generic IOCTL** request, 23H for **get logical device**, and 24H for **set logical device**.

The changes in the programming interface introduced by DOS 3.2 are not dramatic, but they are significant. Many of the low-level disk I/O functions once accessible only through BIOS are now available at the operating system level, so programs that need such low-level control can be made more independent of the hardware on which they are running. This is in preparation for the multitasking protected mode operating system for 80286 and 80386 machines, within which a high degree of isolation from the hardware will be required.

The evolution of DOS capabilities, even from version 2.0, has been impressive. But the operating system has grown in size as well as capability, as demonstrated in tables 2 and 3. The resident size in memory was calculated as the difference between total memory and memory available as reported by CHKDSK after booting up each version in its bare-bones default configuration straight out of the box. The size of the transient portion of COMMAND.COM was determined by examining the topmost segment of memory with a debugger in order to find the lowest address with nonzero contents.

The tabulation of file sizes brings up some interesting points. Many simple DOS functions are performed by files that seem inordinately large for the amount of useful work they perform. LABEL, COMP, and ATTRIB, the last even in its slimmer 3.2 size, are the most obvious examples. This is attributable to their being written in Microsoft C, not assembly language. The resident size of version 3.2 has grown by almost 10KB, or more than 25 percent, from version 3.1. The addition of a built-in driver for 3½-inch disks cannot account for all of this growth, and JOIN and SUBST are reduced significantly, each by about 7KB. Perhaps the resident portion of DOS now has to support functions that previously were coded in these external utilities; the new IOCTL functions are possibilities.

EVOLVING DOCUMENTATION

Beginning with version 2.1, the documentation for DOS was packaged in

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three volumes. A reference manual and a user's guide (featuring the infamous yellow bird) were supplied with the program disks. The reference manual, although comprehensive and authoritative, is totally incomprehensible to anyone who does not already have some experience with operating systems. The user's guide is an insult to the average user's intelligence and does not cover nearly enough of the useful operations. Rewritten for version 3.2, the user's guide now includes some introductory material on tree-structured directories, but it is still not a suitable tutorial for newcomers. Also, the bird is still very much in evidence.

The third volume, the *DOS Technical Reference*, is, for the most part, a model of concise exposition. Its major failing is its price—an exorbitant $109. Prior to DOS 2.1, the same information was provided at no charge as an appendix in the one and only DOS manual. The layout and organization of the separate volume, however, are first rate. A single complaint is that the chapter on memory management is nearly devoid of information on that subject.

Previous users do not have to purchase a new *Technical Reference* for DOS 3.2. Those who register their copies of the newest version will receive an update that replaces the entire earlier manual. Except for the additions of the new IOCTL functions and corrections of some minor errors, the contents are basically the same.

One change is evident, and it concerns a rather interesting passage. In previous versions of the reference, the discussion of function 2AH (**get date**) of INT 21H contains a remarks section that reads as follows, "If the time-of-day clock rolls over to the next day, the date is adjusted accordingly, taking into account the number of days in each month and leap years. Unless you are using the IBM ROM which ignores date rollovers past the first."

In DOS 3.2, the second sentence has been deleted. (This must have been a remark placed by Microsoft into the generic MS-DOS reference book, and IBM simply missed it.) That oversight, but not the ROM problem to which it referred, has been corrected.

COPING WITH TWO VERSIONS

The current state of DOS includes two versions, 2.1 and 3.2, which are far from identical. Developing software for two different versions of the same operating system requires care to step around their incompatibilities. Usually this means designing for the earlier version,

but even this does not always ensure compatibility with later editions (as will be discussed). As a further hindrance, some of the incompatibilities are either poorly documented or not at all.

One important consideration is that SYS may not be used to copy an earlier version of DOS onto a disk formatted with a later version, unless the formatting was done with the /B option. This is not unique to the two current versions, but has been documented ever since DOS 2.0. The documentation for the FORMAT command states that if a disk is formatted without /B, only the same version of DOS can be placed on it with SYS. Actually, this restriction is refuted on two counts.

First, a *later* version can be placed onto the disk formatted with SYS from an *earlier* version, even if the formatting was done without /B. In this way, a disk may be updated to a later version of DOS without reformatting. Note that this capability is at odds with the documentation and therefore is not guaranteed in future versions. Second, despite the documentation's warning that an earlier version of DOS cannot be placed onto a disk with SYS, such an operation appears to succeed—the two hidden files IBMBIO.COM and IBMDOS.COM are properly copied to the target. However, the resulting disk will not boot; it hangs the system at a very early stage of loading, just after IBMBIO.COM gets control.

The reason is that SYS in this case copies to the target disk only two of the three hidden components of DOS: the two hidden files. It misses the boot record, which is a vital part of DOS. The code in the boot record loads IBMBIO.COM and passes some data to it, but each version's boot code stores those data at a different address. Each version of IBMBIO looks for the data in a different place and finds garbage if the data were not written by the corresponding version of the boot code. Besides the executable boot code, the boot record contains additional information, such as the DOS version under which the disk was formatted. During a SYS operation, the boot record is rewritten only if a newer version of DOS is being copied. The /B option causes FORMAT to write a DOS 1.x boot record, so that a subsequent SYS with any higher version will rewrite the boot record along with the two hidden files, maintaining version compatibility among the three components.

Another significant difference between the versions is in the location of the system loader that handles the EXEC function. In DOS 2.x, the loader resides in the transient portion of COMMAND.COM, but in DOS 3.x it is located within the resident portion of DOS. For programs loaded by COMMAND.COM, it makes no difference which portion of the command processor performs the loader functions. The new structure is very significant for user programs that issue EXEC calls by way of function 4BH of INT 21H. With DOS 3.x, the transient portion of COMMAND.COM need not be in memory when the EXEC call is issued. This saves the time of looking for and possibly reloading the transient portion, and, more importantly, it does not disturb the contents of high memory.

One possibly critical undocumented difference between the two versions is in the way each handles command-line parameters. Both build FCBs (file control blocks) from the first two parameters on the command line. In DOS 2.1, the file names are scanned only as far as the first slash; the remainder of the line is ignored. In DOS 3.x, each parameter preceded by a slash is considered, for the purposes of building FCBs, as two parameters; the single character following the slash is one and the remainder of the word is the other. For example, the command line PROG /ABC under DOS 2.1 would create no FCBs, but under DOS 3.x, it would create two: the first for *A*, the second for *BC*. The reasons for this situation are unclear. It may, however, be a bug in DOS 3.2 because DEBUG 3.2 builds FCBs just as under 2.1.

This anomaly can cause programs to behave erratically, a situation that can be especially frustrating to resolve because the problem cannot be traced under DEBUG 3.x. This is one of the few instances in which a program running under DEBUG behaves differently than when it is running directly under DOS. The CMDLINE.ASM program included here (as listing 1) demonstrates the handling of command line parameters. After assembling and linking, it must be converted to a .COM file with EXE2BIN. When CMDLINE is run, it displays the file-name portions of the two FCBs from offsets 5CH and 6CH of the PSP (program segment prefix); each file name is preceded by a numeric drive ID (0 for default, 1 for A:, and so on).

The building of FCBs from command-line parameters is a carry-over from CP/M and is not too important in current DOS versions. FCBs are rarely used anymore, and DOS parses only parameters that are bare file names without paths. But the automatic parsing of

the command line and the breaking out of the first two words into the FCBs often was useful, even if the words were not file names. Under DOS 3.x, the program cannot be sure if the contents of either of the FCBs truly reflect the command line entered by the user. Programs now should do their own parsing of the entire command line as passed at offset 80H of the PSP; that is the same under all versions of DOS.

The last set of differences between the two DOS versions concerns the processing of subdirectories with various functions of INT 21H. In DOS 2.x, many of the FCB-oriented functions carried over from DOS 1.x would process subdirectories in the same way as normal files, provided that such operations were performed through an extended FCB with the proper attribute byte. In DOS 3.x, subdirectories generally cannot be processed as data files. The specific differences by function are outlined as follows:

Function 0FH, open file. DOS 2.x can open a subdirectory as a data file (see "Dipping into Directories," Ted Mirecki, February 1985, p. 67). This useful capability has been removed from DOS 3.0 and subsequent versions, and it is a real loss. In version 3.x, the only way for a program to read and write the data in subdirectories is to trace their allocation chains through the FAT.

Function 11H, find first. DOS 2.x versions return a "file not found" error for subdirectories with names of . (current directory) or .. (parent directory), but DOS 3.x finds them. The parent directory is found only if it is not the root. When found, the subdirectory's full name is written to both the result FCB and the search FCB. When the search FCB contains names other than . or .., the name of the file matching the search pattern was written only to the result FCB at the DTA (disk transfer address). No DOS version can find subdirectories when names are specified as .? or .*, but all versions will find the . and .. entries as the first two when the search pattern is *.* (all files). In the latter case, the resultant FCB is filled in with . or .., not the actual names of the directories. (Also see the explanation of function 4EH below.)

Function 13H, delete file. Version 2.x can delete a subdirectory if an extended FCB is provided. The directory is deleted whether or not it contains files. If it does, the file data become stranded; each file becomes a cluster chain in the FAT for which no root entry exists in the directory. These lost clusters can be recovered subsequently by CHKDSK, but their names are lost in the process. DOS 3.x sensibly fixes this problem by disallowing the deletion. Function 41H, which deletes files through an ASCIIZ string, refuses to delete subdirectories in all DOS versions.

Function 4EH, find first. This is equivalent to function 11H, except that this function uses null-terminated ASCIIZ strings instead of FCBs. It operates exactly as function 11H does, except that the search string is never modified.

Function 56H, rename file. DOS 2.x does not rename a subdirectory with this function, but DOS 3.x does. All versions will rename directories with function 17H, the FCB-oriented rename function, if an extended FCB is used (refer to "Replacing RENAME," Tech Notebook 34, Ted Mirecki, April 1985, p. 41).

STILL A WINNER

DOS has come a long way in five years. Perhaps a case can be made that it has not come far enough—it certainly has its faults. The A> prompt is as intimidating as ever to new users, and the keyboard interface, with its limited editing of an invisible template line, is a joke. Only BACKUP, RESTORE, and FORMAT return ERRORLEVEL codes, greatly limiting what may be done with DOS commands within batch files. No operating system can be considered complete without a text editor, but EDLIN is such an embarrassment that instructions supplied with most applications describe how to use COPY to create BAT and CONFIG.SYS files.

Despite the difficulties at the user level, DOS is a comprehensive and rich development environment for the professional software developer. Moreover, future enhancements promised by IBM and Microsoft ensure its continued usefulness as it keeps step with changes in both hardware and software.

PC-DOS 3.2: $95
IBM Corporation
Entry Systems Division
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Montvale, NJ 07645
Contact the local IBM dealer,
800/426-2468
CIRCLE 341 ON READER SERVICE CARD

Ted Mirecki is a corporate planner who is responsible for developing decision support systems on a variety of hardware.

LISTING 1: CMDLINE.ASM

```
COMMENT "       CMDLINE.ASM  by Ted Mirecki, June 1986.
    Program to demonstrate building of FCB's in the PSP from
    command line parameters.
    Must be converted to a COM file with EXE2BIN after linking.
    When running, use any parameters with or without slashes, but
    do not use $ in parameters.
"
CODE    SEGMENT
        ASSUME  CS:CODE, DS:CODE

        ORG     5CH     ;1ST FCB IN PSP
DRIVE1  DB      ?       ;DRIVE ID BYTE
FILE1   DB      11 DUP(?)       ;NAME AND EXTENSION
END1    DB      ?
        ORG     6CH     ;2ND FCB
DRIVE2  DB      ?
FILE2   DB      11 DUP(?)
END2    DB      ?
        ORG     80H     ;PARAMETER AREA
PARMLEN DB      ?
PARMS   LABEL   BYTE

        ORG     100H    ;BEGINNING OF CODE
CMDLINE PROC
        MOV     AL,'$'  ;INSERT END-OF-STRING MARKER..
        MOV     END1,AL ;  AT END OF 1ST FILENAME...
        MOV     END2,AL ;  AND 2ND FILENAME
        ADD     DRIVE1,30H      ;CONVERT DRIVE ID'S
        ADD     DRIVE2,30H
        LEA     DX,CRLF1        ;DISPLAY MARKER STRING
        MOV     AH,9
        INT     21H
        LEA     DX,DRIVE1       ;DISPLAY 1ST DRIVE & FILENAME
        MOV     AH,9
        INT     21H
        LEA     DX,CRLF2        ;DISPLAY ENDING MARKER
        MOV     AH,9
        INT     21H
        LEA     DX,CRLF1        ;REPEAT FOR 2ND FILENAME
        MOV     AH,9
        INT     21H
        LEA     DX,DRIVE2
        MOV     AH,9
        INT     21H
        LEA     DX,CRLF2
        MOV     AH,9
        INT     21H
        INT     20H ;EXIT
CMDLINE ENDP
CRLF1   DB      0DH,0AH,'|$'
CRLF2   DB      '|',0DH,0AH,'$'
CODE    ENDS
        END     CMDLINE
```

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Supports up to 9600 baud, ASCII or binary, any parity or word length, 8250 UARTs, Xon/Xoff and Xmodem, WideTrack receive. Specify: S0750 & Compiler. List: **$185**, Us: **$139**

PRE-C *Pick the Lint from Your Program*

Pre-C is like UNIXs lint. It finds problems your compiler won't. Problems that a debugger will have trouble figuring out. Even problems which will cause trouble with other compilers.

Compilers see one module at a time. Modules only meet at link time. Pre-C looks at *all modules at once* and reports conflicts in data type declarations; function call parameters which disagree with functions, machine-dependent expressions which inhibit portability. It spots obsolete usage (even C changes), casts with suspect conversions, variables never used, functions never called, unreachable code. Adheres to UNIX System III compile standard to ensure your portability. Ask for: P0590, List: **$395**, Ours: **$279**

DAN BRICKLIN'S DEMO PROGRAM

Storyboard Your Program

The Legendary One has created Metaphor Two when the rest of us are still on Zero. Dan's first was the original electronic spreadsheet (VisiCalc™). This one is for programmers.

Words don't express program ideas because programs are screens! Dan's Demo creates slide shows. Create a screen — a snapshot of your planned product as it runs. Anything goes: words, borders, box rules, inverse and underlining of monochrome, fore- and background color. Copy this "slide" to an empty screen. Change it a little, to show the next instant of run-time. Do it again. Presto, a whole slide show of your program in action.

All 250 characters and attributes are available from scrollable lists which pop to the screen. All commands are layered in Lotus-style pop-up menus. Frequent choices mapped to function keys as well. 80x25 character mode, not bit-mapped.

Screen areas can be blocked for cut and paste or filled with color or characters, even blink. Slides can overlay on others, can be shuffled, deleted. Slides can proceed at time intervals or branch anywhere in the slide sequence depending on user keyhits.

Invaluable to prototype the program you are about to write, to position the labels, choose the color decor, smoothe out the keystroke interface. Or load the "capture" utility and snapshot the screens of any running program for an instant slide show.

Each copy entitles you to redistribute fifty of the slide projector program that runs demos. Plain manual, no binder keeps price of big product small. "Might . . . become *the* essential tool in . . . user interface prototyping," *Tech Journal*. Ask for: N0100. List: **$75** US: **$69**

BASTOC OPTIMIZES!

Translates BASIC Into C

For a trifling price, BASTOC™ moves truckloads of BASIC code over to C. It's a translator which takes in Microsoft Extended BASIC and emits pure K&R C for Lattice 3.0. It will optionally convert your program into a single monolithic C function or decompose it into separate functions, one for each GOSUB label.

Version 2's optimization dramatically reduces execution time. Converts to integers those variables in BASIC programs which do not need floating point. Where BASIC uses full assignment statements to increment counters, BASTOC converts to C's compact form. Strings dynamically allocated ridding your application of BASIC's catatonic halts for garbage collection. Creates structure of even convoluted BASIC code. Huge worksaver.

Ask for:	List:	PC Brand:
S0375	**$495**	**$399**

Shopping List for the Power Workbench

	LIST	OURS
ASSEMBLERS & DEBUGGERS		
Advanced Trace-86 *Morgan, ASM Interpreter*	175	**149**
Codesmith-86 *Debugger by Visual Age*	145	**109**
Cdebugger *by Micro-Software Developers*	165	**139**
CSD Debugger *C source level by Mark Williams*	75	**75**
C-Sprite Debugger *by Lattice, source level*	175	**139**
Microsoft Macro Assembler *with Utilities*	150	**109**
Periscope I Debugger *Data Base Decisions*	295	**269**
Periscope II *Data Base Decisions*	129	**111**
Pfix86 *by Phoenix, Assembly level debugger*	195	**149**
Pfix86 Plus *by Phoenix, Symbolic Debugger*	395	**279**
BASIC LANGUAGE		
BetterBASIC *Summit Software*	195	**165**
BetterBASIC Utilities *8087 Math Support*	99	**85**
Btrieve Interface	99	**85**
Run-Time Module	250	**225**
Microsoft BASIC Interpreter *for XENIX*	350	**295**
Microsoft QuickBASIC Compiler *full BASICA*	99	**79**
Professional BASIC *by Morgan*	99	**79**
8087 Math Support	50	**47**
RM/BASIC *by Ryan-McFarland*	600	**480**
True BASIC *True BASIC Inc*	150	**119**
Run Time Module	500	**420**
True BASIC Libraries *Btrieve, Asyn, Sort, etc.*	Var	**Call**
C COMPILERS		
C-86 Compiler *Computer Innovations*	395	**289**
Lattice C Compiler *from Lattice*	500	**299**
Let's C Compiler *by Mark Williams*	75	**69**
with CSD Source Level Debugger	150	**129**
MWC-86: Mark Williams C Development	495	**369**
Microsoft C Compiler *4.0*	450	**295**
C INTERPRETERS		
C-Terp *by Gimpel Software*	300	**249**
Instant C *by Rational Systems*	500	**395**
Interactive-C *by IMPACC with debugging*	249	**219**
RUN/C Professional *from Lifeboat*	250	**185**
RUN/C *without Loadable Libraries*	120	**109**
TEXT EDITORS		
Brief *from Solution Systems*	195	**CALL**
Epsilon *by Lugaru Software, like EMACS*	195	**169**
FirsTime *by Spruce Technology, C syntax*	295	**229**
Kedit *by Mansfield, similar to Xedit*	125	**115**
LSE, the Lattice Screen Editor *Multi Window*	125	**100**
Pmate *by Phoenix, with Macros*	225	**159**
Text Management Utilities *Grep, splat, diff, etc.*	120	**100**
Vedit *by Compuview*	150	**119**
Vedit Plus *by Compuview*	225	**180**
FILE MANAGERS		
Btrieve *by Softcraft, no royalties*	250	**195**
Btrieve Network *by Softcraft*	595	**465**
c-tree *by FairCom — no royalties, source*	395	**329**
dBC *dBASE file manager from Lattice*	250	**195**
with source	500	**390**
dbVista *single user DBMS by Raima*	195	**159**
with source	495	**429**
dbVista *multi-user DBMS*	495	**429**
with source	990	**849**
Opt-Tech Sort *Can sort Btrieve files*	149	**119**
SCREEN DESIGN		
Curses *by Lattice, UNIX screen designer*	125	**99**
with Source	250	**199**
On-Line Help *from Opt-Tech Data*	149	**119**
Panel *by Roundhill, no royalties*	295	**229**
View Manager for C *by Blaise*	275	**209**
Windows for C *Vermont Creative Software*	195	**149**
Windows for Data *includes Windows for C*	295	**259**
ZView *Data Management Consultants*	245	**199**

	LIST	OURS
GRAPHICS		
Essential Graphics *by Essential, no royalties*	250	**210**
GSS Graphics Development Toolkit	495	**399**
GSS Kernel System *by Graphic Software*	495	**399**
GSS Kernel System *for IBM RT*	795	**676**
GSS Metafile Interpreter	295	**249**
GSS Plotting System	495	**399**
Halo Graphics Kernel System	300	**219**
with Dr. Halo II, by Media Cybernetics	440	**299**
COMMUNICATIONS		
Asynch Manager *by Blaise, for C or Pascal*	175	**149**
Greenleaf Communications *by Greenleaf*	185	**139**
Software Horizons Pack 3	149	**119**
UTILITY LIBRARIES		
Blaise C Tools Plus C Tools 2	175	**149**
Blaise C Tools	125	**109**
Blaise C Tools 2	100	**89**
C Food Smorgasbord *by Lattice*	150	**109**
C Utility Library *by Essential, 300 functions*	185	**139**
Greenleaf Functions *by Greenleaf Software*	185	**139**
PforCe *by Phoenix, vast library*	475	**349**
Software Horizons *Packages*	Var	**Call**
TopView Tool Basket *by Lattice, source avail*	250	**199**
Vitamin C *by Creative Programming*	150	**139**
DEVELOPMENT TOOLS		
Code Sifter *by David Smith Software, Profiler*	119	**99**
C-Worthy *by Custom Design Software*	295	**269**
C-Worthy for Network *Menus, help, errors*	495	**449**
Dan Bricklin's Demo Program *Prototyper*	75	**69**
LMK from Lattice *by Lattice, "make" like UNIX*	195	**149**
PC-Lint *by Gimpel Software, after UNIX's "lint"*	139	**125**
PFinish *by Phoenix, EXE performance analyzer*	395	**279**
Plink86 *by Phoenix, Overlay Linker*	395	**279**
Plink86 Plus *Utilizes memory for overlays*	495	**359**
Pmaker *by Phoenix, like UNIX "make"*	195	**149**
Pre-C *by Phoenix, UNIX "lint"-alike*	395	**279**
Pfantasy Pac *six Phoenix products*	1295	**895**
OTHER TOOLS		
BASTOC *by JMI, convert BASIC to C*	495	**399**
BASIC-C *BASIC's functions added to C*	175	**139**
The HAMMER *by OES Systems*	195	**179**
PASM86 *by Phoenix, Macro Assembler*	295	**219**
PTel *by Phoenix, Binary File Communicator*	195	**149**
Rtrieve *by Softcraft, Btrieve Report Generator*	85	**75**
Xtrieve *by Softcraft, Query Utility for Btrieve*	195	**175**
FORTRAN COMPILERS & UTILITIES		
ACS Time Series *by Alpha Computer Service*	495	**469**
Forlib- Plus *by Alpha Computer Service*	70	**59**
Microsoft FORTRAN *Links with Microsoft C*	350	**219**
Microsoft FORTRAN *for XENIX*	495	**389**
Pro FORTRAN *by Prospero*	390	**345**
RM/FORTRAN *by Ryan-McFarland*	595	**399**
Scientific Subroutine Library *by Peerless*	175	**149**
Scientific Subroutine Package *by Alpha*	295	**269**
The Statistician *by Alpha Computer*	295	**269**
Strings & Things *by Alpha Computer*	70	**59**
OTHER LANGUAGES & UTILITIES		
Microsoft COBOL Compiler	700	**499**
Microsoft COBOL Compiler *for XENIX*	995	**795**
Microsoft COBOL Tools *with Source Debugger*	350	**259**
Microsoft COBOL Tools *for XENIX*	450	**333**
Microsoft Lisp *New Common Lisp*	250	**189**
Microsoft MuMath *Includes MuSimp*	300	**199**
Microsoft Pascal Compiler *Links with M'soft C*	300	**199**
Microsoft Pascal Compiler *for XENIX*	495	**415**
Pro Pascal *by Prospero, ISO Validated*	390	**345**
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RM/COBOL 8X *ANSI 85 COBOL*	1250	**995**

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Compiler-Compatible Interpreter, Editor, Debugger

Earlier C interpreters were miraculous compromises. Interactive-C™ shows how far C interpreters have come. More than an interpreter, Interactive-C is a fully-integrated development environment: a complete K&R interpreter bound tightly to its own editor and debugger.

Slice through programming projects like a hot knife through butter. Extensive error-checking insures immediate detection of program misbehavior. State of the art debugging tools include breakpoints, watchvalues, several stepping options and interactive viewing and modification of variables. An Interactive-C exclusive lets you interrupt to edit and "continue" from where you left off. Eliminates plodding replays of already debugged code — the ball and chain of other interpreters.

Operate Interactive-C using adjustable edit, command, and status windows. Toggle a second screen showing only your program's output — never any crowded intermixing. Or, boost productivity with twin CRTs. Load object code of functions you have already compiled. Or of commercial libraries. Interactive-C has immediate mode, syntax checking both as you type and run, and cursor positioning precisely pointing at an error, not possible with incremental or pseudo-compilers which leave source code behind.

100% compiler compatible — right down to header files and library calls. Port programs between Interactive-C and your compiler with no modifications whatever — not even tricky areas of dynamic memory allocation and I/O.

Specify:	List:	PC Brand:
E950 & Compiler	$249	$219

RUN/C PROFESSIONAL

C Interpreter Links Binary Libraries

Run/C comes in an apprentice and pro version. The professional model dynamically loads and unloads multiple binary function libraries like C-Food Smorgasbord™ and Halo Graphics™ — potentially any library compiled with Lattice's large model. Inside this interpreter your C program can reach for functions in the best of commercial libraries.

This C interpreter behaves like PC BASIC meets WordStar®. Use fullscreen editing to create a program. RUN it. If it stumbles, LIST it, EDIT it, RUN it again, fix it again. Use familiar commands like LOAD, MERGE, SAVE, FILES, even TRON and TRACE.

Ideal for program development. Put up code at high speed, try out things devil-may care, let RUN/C find your malaprops. Blast away until tight little code segments are undyingly faithful.

Lots more features: system interrupts, a shell command to invoke any operating system command without leaving Run/C, debugging aids ingeniously installed as a Run/C function. Call for debugging conditionally from within your program, a specific function or a menu of aids including immediate mode, single-step tracing, changing of variable values.

Manual shows how to develop the interface to a commercial library, using the Lattice compiler (a must!). Link your own function archive the same way. (320k minimum; 512k recommended to fit libraries.)

Ask for: S0950 List: $250 PCB: $185

PLINK86 & PLUS

Cached Overlays Maximize Memory Use

Long the overlord of overlay linkers, standard Plink86 shoehorns large programs into small machines by sharing memory, swapping program segments in from disk. A 512k program could run in a 128k machine, for example. The Plus version goes beyond: if it finds itself in a larger machine, it moves whatever program overlays that fit into leftover memory. Overlays now swap at memory speed not disk speed. It also can automatically restore a displaced overlay to which a subsequently called overlay must return, and assign library modules to a program's root segment or its overlay areas.

Plink86-Plus: List: $495. Us: $359. Plink86: List: $395. Us: $279

GSS GRAPHICS SYSTEM

ANSI CGI STANDARD!

Leave the Device Driving to GSS

GSS™ has reconfigured two components of its comprehensive graphics tools to conform with the ANSI Computer Graphics Interface (CGI) standard.

At the heart of the system is the Development Toolkit which contains all language interfaces and device drivers for keyboards, mice, joysticks, tablets, printers, plotters, cameras, and more. Drivers house management of vector graphics (plotters) and bitmaps used by raster input devices (scanners) to insulate the application program from concern for device idiosyncracy. No one else has implemented CGI that way. It means your programming remains generic; just switch drivers and the same program will drive a different device.

GSS Kernel™ conforms to level 2b of ANSI's Graphical Kernel System (GKS) and contains all its needed drivers and language bindings. Kernel has macro level tools to draw and color an object, store the sequential instructions, and recreate the object on its own, as well as segment it, transform it, etc. So powerful, a single command may represent several score lower level statements.

Plotting has the equivalent GKS tools for graph and chart generation and their captioning: hand it apples and oranges, say "pie", and it bakes the numbers into a digestible display for screen or plotters.

Kernel and Plotting have tools to convert images they create to ANSI Computer Graphics Metafiles (CGMs), a tokenized standard for storing every form of graphic image as data. The Metafile Interpreter reads the contents of a CGM and interprets it with full CGI capability for recreation on various devices.

Quality software? IBM thinks so. They sell the GSS series under their own label.

Unit royalties and annual fees have been instituted for redistribution. Needs 256k.

Ask for:		List:	PC Brand:
GS010	CGI Dvlpmt Toolkit	$495	$399
GS020	Kernel System	$495	$399
GS025	Kernel for IBM RT	$795	$676
GS030	Plotting System	$495	$399
GS040	Metafile Interpreter	$295	$249

LATTICE C COMPILER

Major Upgrades to the Best Selling C Compiler

Lattice now embraces key UNIX™ enhancements which have entered the language since K&R: void functions returning no value, enumerated data types to assign stepped values to variables, data passing between structures by assignment.

The greatly expanded libraries (325 functions!) enable the file sharing and record locking provisions of DOS 3.1, provide a full complement of transcendentals, and a host of utilities to mimic the UNIX and XENIX™ environments.

Lattice 3.0 defaults to the ANSI proposed standard when you need strict adherence, but command line options restore leniency. And it adopts ANSI checking of external function arguments by data type to kill bug swarms when modules join up at link time.

Lattice now delivers smaller .EXE files, boasts very fast link times and a more efficient aliasing algorithm. New options generate code to use 80186 and 80286 features; 8087 of course sensed and utilized. Lattice has enjoyed pre-eminence so long that developers have created far more snap-on tools for Lattice C than any other compiler. William Hunt's *PC Tech Journal* review of 12 compilers awarded Lattice the only "very good" rating for add-on library availability.

Ask for:	List:	PC Brand:
S0100	$500	$299

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We ship anywhere. Phone or Telex your order. Credit cards: We need card number, expiry date, name and address of card. Or wire funds to PC BRAND, c/o Chemical Bank, 126 East 86th St., NY NY 10028, Account No: 034-016058. **We'll ship immediately** and confirm by Telex if you provide number.

BETTER BASIC

Convert Microsoft BASIC. Structured, Compilable.

Combines the familiarity of BASIC with the best features of C, Pascal, and Modula 2, yet BetterBASIC is 100% compatible with Microsoft's GW™ BASIC and IBM BASICA including graphics, sound, and assembly language calls. So load your old programs and RUN. SAVE and they are converted automatically to BetterBASIC!

It's big: Needs 192k; programs can go to the PC's full 640k. It's comfy: Behaves like M'soft BASIC at the interactive level, with a full-screen editor, direct statement execution, and always poised to RUN. It's fast: Each statement checked and compiled once, not every time encountered. Sieve runs *6 times faster* than with M'soft.

C-like structures house file records so goodbye to FIELD, MKI$, CVD, LSET, etc. Named "procedures" replace GOSUBs to linenumbers. Lots more features: built-in linker for compiled modules; trace; debugging breakpoints; cross-reference command; 32k strings; DOS and BIOS calls and interrupts; recursion. Run-time module stores object code for redistribution.

Ask for:		List:	Us:
S1200	BetterBASIC	$195	$165
S1201	Run-time Module	$250	$225
S1202	8087 Interface	$ 99	$ 85
S1205	Btrieve Interface	$ 99	$ 85

BTRIEVE

ASK ABOUT XTRIEVE & RTRIEVE

Queen B-tree File Manager Abdicates Royalties

There's no longer a tithe to incorporate Btrieve™ in applications, a welcome proclamation if royalties would ruin your profit margins. Btrieve takes complete charge of all file creation, indexing, reading, writing, insertion, deletion, space recapture, forward and backward searching. It builds function call "commands" right into the language you use: interfaces to C, Pascal, BASIC, and COBOL, with sample programs in all four, come with each copy.

Btrieve has mainframe specifications! Its balanced-tree indexing scheme finds any key in a million in four or less accesses. Files may have up to 24 indexes; fixed record length to 4090 characters; indexes up to 255 characters; files of 4 billion bytes. Can even extend a file across two drives — even two hard disks!

Version 4.x speeds DOS interaction for large multiply-keyed files; enables variable length records of virtually any length; verifies accuracy (optionally) with read after write, useful in gritty environments; offers password and data encryption.

There's also Xtrieve, for Btrieve file inquiry and data manipulation, and Rtrieve for report writing. All three in versions for any network that supports the MS-DOS 3.1 file sharing function.

Ask for:		List:	PC Brand:
S0650		$250	$195
S0652	Network Version	$595	$465

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Shipping & Handling: U.S.: UPS Surface: 1st product $6, each add'l $3. UPS 2nd Day Air: 1st product $10, each add'l $4.50. UPS Next Day Air or Federal Express 1-2 Day Air: 1st product $18, each add'l $6. FedEx Next Day 10 AM: 1st product $28, each add'l $7. International: Charges vary by destination and carrier. $10 per shipping container for export forms. Air parcel post at your risk beyond collected insurable amount.

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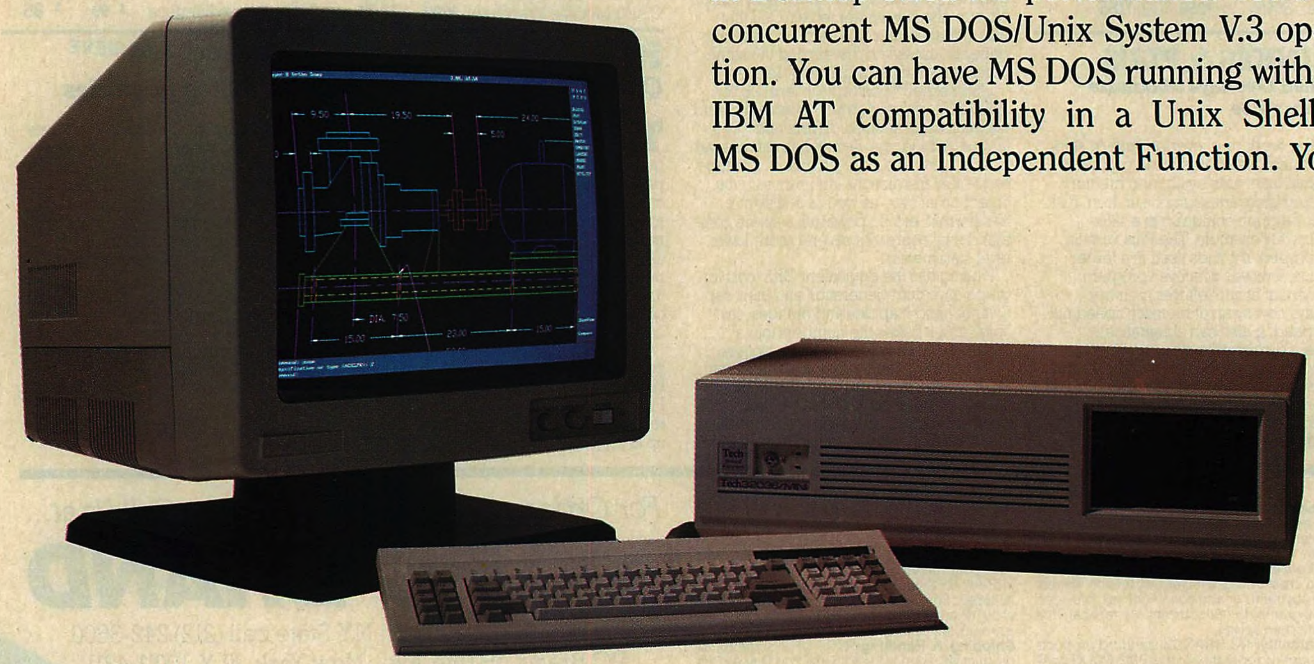

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have a complete Port of Unix System V.3 with Berkeley 4.2 Enhancements in Concurrent Operations. . . . .and, the following features:

- 32 Bit 32036 CPU for Unix System V
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- PC Net 2 MB/second Network Adaptor and Driver available
- Optical Mass Storage to 16 Gigabytes available
- 9 Track Reel Tape Sybsystems available

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TECH PC

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COMPATIBILITY

PERFORMANCE

OUT FROM THE SHADOW OF IBM:

HP Vectra

Hewlett-Packard has built an 80286 machine that offers many innovative and convenient features, while maintaining a good measure of AT compatibility.

STEVEN ARMBRUST and TED FORGERON

For several years, Hewlett-Packard has introduced attractive and innovative personal computers that have failed to attract much attention because of incompatibilities with the IBM standard and a lack of third-party software support. With the introduction of the Vectra, HP's 80286-based personal computer, the company has made a concerted effort to build a computer that will satisfy the existing HP customer base and be completely compatible with the IBM PC/AT. The Vectra, like other HP machines, suffers from incompatibilities that may prevent its ultimate success as an AT compatible; however, it is teeming with imaginative touches that reflect a company concerned with human engineering.

The machine tested in this article contained 640KB of memory, a 20MB hard disk, two diskette drives (1.2MB and 360KB), an asynchronous communications port, a parallel printer port, a multimode color adapter, a color monitor, and the touchscreen option. The accompanying sidebar lists the features available with the Vectra.

The most noticeable feature of the Vectra is its size. With a system unit measuring 16.7 inches by 15.4 inches by 6.3 inches, it is approximately 30 percent smaller than the AT. Photo 1 compares the machines' footprints.

The small footprint of the Vectra has its price. To achieve a portion of the size reduction, HP places some of the circuitry normally found on the system board onto a processor extension card that fits into a special slot next to the regular expansion slots. This shrinks the size of the system board so that it can fit into the small system unit. The remainder of the size reduction is obtained by limiting the amount of room for internally mounted storage devices.

Unlike the AT, which has two storage bays that can hold as many as six half-height devices, the Vectra has one storage bay. This means that the Vectra can hold only two diskette drives and a

PHOTOGRAPH • MARC DAVID COHEN


HEWLETT PACKARD
Vectra

PHOTO 1: *System Unit Footprint*

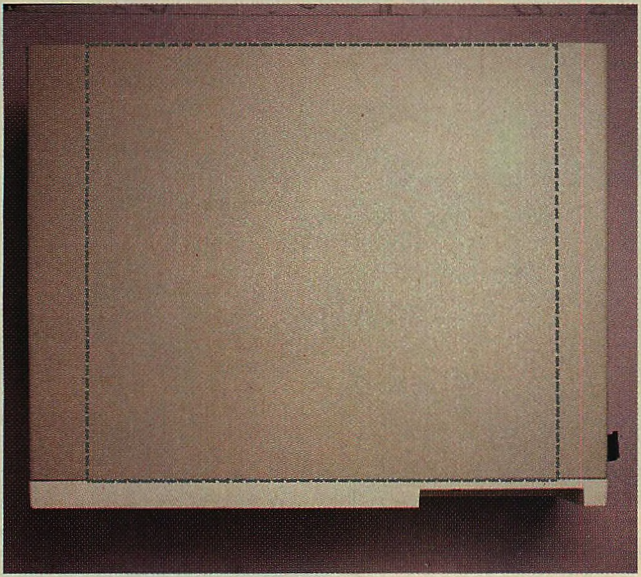

PHOTO 2: *Keyboard Comparison*

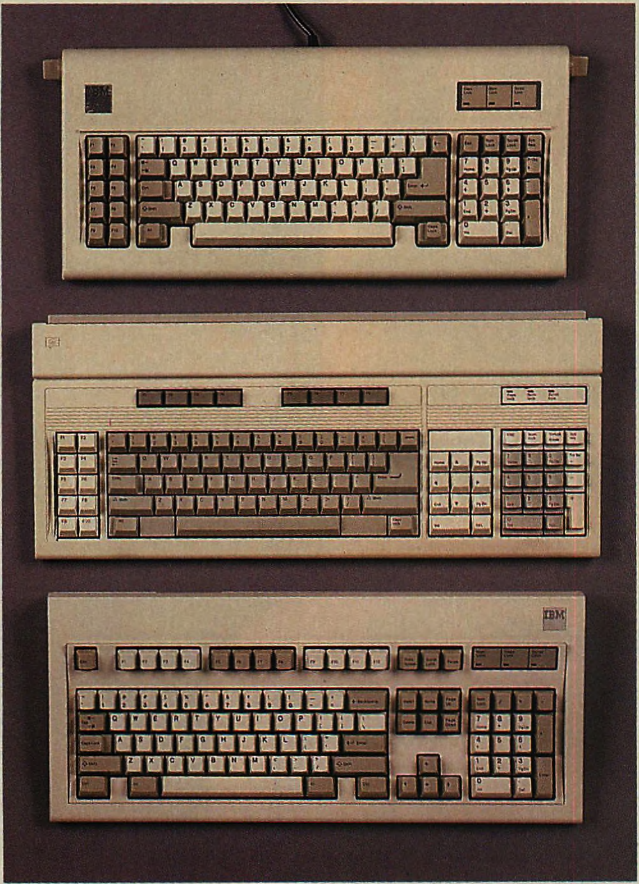

PHOTO 3: *Vectra Styling*

PHOTO 4: *Inside the System Unit*

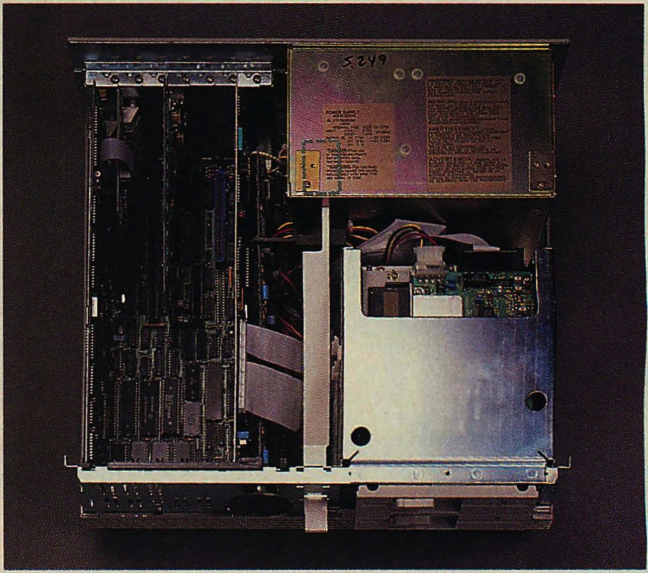

PHOTO 5: *Slide-rail Mechanism*

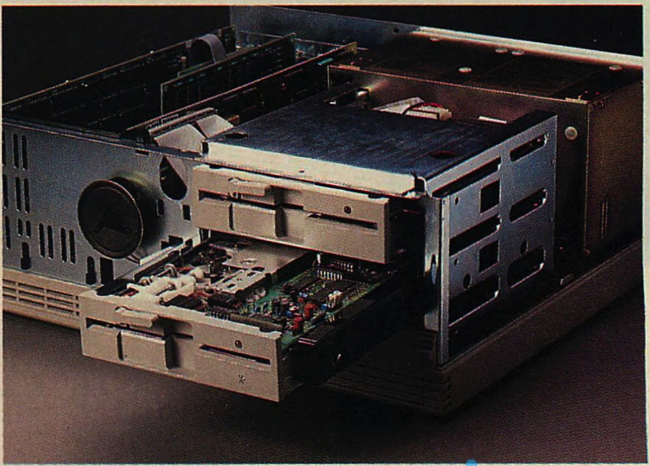

Photo 1: The Vectra has a slightly smaller footprint than the AT, but as a result, it contains only one storage bay.
Photo 2: The Vectra keyboard (center) more closely matches IBM's enhanced keyboard (bottom), than the AT (top).
Photo 3: Positioned low on the front panel, the hard-disk indicator light is easily hidden by the keyboard.
Photo 4: The on-off switch extends from the front of the unit to the power supply. The outline shows the 80287 socket.
Photo 5: The Vectra uses a slide-rail mechanism that allows easy drive removal, without taking out any screws.

20MB half-height hard disk or one diskette drive and a 40MB full-height hard disk. The machine contains no extra power connector or additional connector on the disk controller to support a second drive. Users who need large amounts of storage or who plan to use the machine as a network file server will be affected by this limitation.

Despite the small footprint of the system unit, the keyboard, which is approximately six inches wider than the system unit itself, requires substantial desktop area. Photo 2 compares the Vectra keyboard with the two AT keyboards. The large keyboard is the result of separate cursor control and numeric keypads, much like the new IBM enhanced keyboard, and a row of eight function keys (the HP soft keys) located along the top of the keyboard. These soft keys can be programmed by HP-specific applications, which can display the key definitions immediately above the keys on the screen.

HP representatives claim that the Vectra keyboard was designed for touch typists and that after becoming accustomed to the keyboard, operators do increase their typing speed. Although the keytops are nicely sculpted, the keyboard has a soft, uncertain feel. Those who think that the original PC and AT keyboards (and not the new IBM enhanced keyboard) exhibit the ultimate in tactile feedback will be disappointed in the Vectra's keyboard. Those who like extremely quick key action without a lot of audible or tactile response may become addicted to the Vectra.

The Vectra keyboard is definitely not plug-compatible with the AT. Instead of the circular IBM keyboard plug, the Vectra uses a connector that resembles an oversized telephone plug. The keyboard is part of HP's HP-HIL (human interface loop), an interface that allows input devices, such as the keyboard, mouse, touch screen, and graphics tablet, to be connected to the computer without requiring expansion slots for adapter cards. With the HP-HIL, devices are daisy-chained; no matter how many devices are used, only one cable goes to the computer. For example, on a computer with several input devices, the graphics tablet can be plugged into the mouse, the mouse plugged into the keyboard, the keyboard plugged into the touchscreen monitor, and the monitor plugged into the computer in the spot normally reserved just for the keyboard. This arrangement works only for HP input devices.

Unlike many of the AT-compatible computers, the Vectra does not come equipped with a keylock switch in its standard configuration, but a keylock is available from HP as an option.

The push-button, on-off switch on the Vectra system unit should serve as a model for all personal computer manufacturers. Positioned in the center of the front panel, it makes the computer as easy to turn on or off as a television set. The switch is recessed to minimize hitting it accidentally (see photo 3). When viewed from inside the system unit, as photo 4 shows, the switch is a simple plastic bar extending from the front of the system unit to the power supply. It can be removed easily when accessing the system unit, and because all the switch circuitry is still inside the power supply, no high-voltage wires are located where they might be touched by users installing expansion cards.

The color monitor tested for this article is another example of HP's human engineering talents. The monitor has a tilt screen that can be adjusted to prevent glare and a swivel base for easy turning of the large monitor.

HP engineers could have put a bit more thought into the location of the hard-disk access light. When the keyboard is placed in its most common position directly in front of the system unit with its legs tilted up, it blocks the disk access light (see photo 3). This does not present any operational problems, but it makes it difficult to confirm that the hard disk is in action.

Asynchronous communications adapters and parallel printer ports are not standard equipment on the Vectra, but the tested machine came equipped with HP's serial/parallel interface card (a $150 option). The connectors on this card are identical to those on the AT. The parallel port has a 25-pin, D-shell, female connector; and the serial port has the smaller 9-pin, D-shell, male connector. The interface card has jumpers to set the port numbers or to disable the serial port.

SETTING VECTRA APART

The Vectra has several features not available with the AT that set this computer apart from others that are billed strictly as AT compatibles. These features include the HP-HIL, the touch-screen display, the extended BIOS (EX-BIOS), soft keys, the Personal Application Manager (PAM), and the multimode display adapter.

As mentioned earlier, the HP-HIL is a special method of connecting input devices to the computer without requiring separate adapter cards or dedicated serial ports. This connection involves a simple daisy-chain of one device to the next, with the last one plugged directly into the system unit. A special chip designed by HP manages all the devices that are connected via the HP-HIL. Approximately 60 times a second, this HP-HIL controller polls the devices to read any input they may have ready and

HP VECTRA VITAL STATISTICS

Model 25: $3,099
256KB memory
Realtime clock
360KB diskette drive

Model 35: $3,229
256KB memory
Realtime clock
1.2MB diskette drive

Model 45: $3,249
640KB memory
Realtime clock
1.2MB diskette drive

Memory capacity on system board
640KB

Display adapters
Multimode; multimode color (CGA compatible with high-resolution text)

Expansion slots
16-bit: 5
8-bit: 2

Remaining available slots
(with serial/parallel card, hard-disk controller, and multimode color adapter installed)
16-bit: 3
8-bit: 0

Extras available

Multimode video adapter	$ 325
Multimode color adapter add-on card	$ 50
Monochrome monitor (for use with multimode adapter)	$ 325
Color monitor (for use with multimode adapter)	$ 995
Touchscreen accessory	$ 300
360KB diskette drive	$ 225
1.2MB diskette drive	$ 275
20MB hard disk with controller	$1,395
40MB hard disk with controller	$2,195
Serial/parallel interface	$ 150

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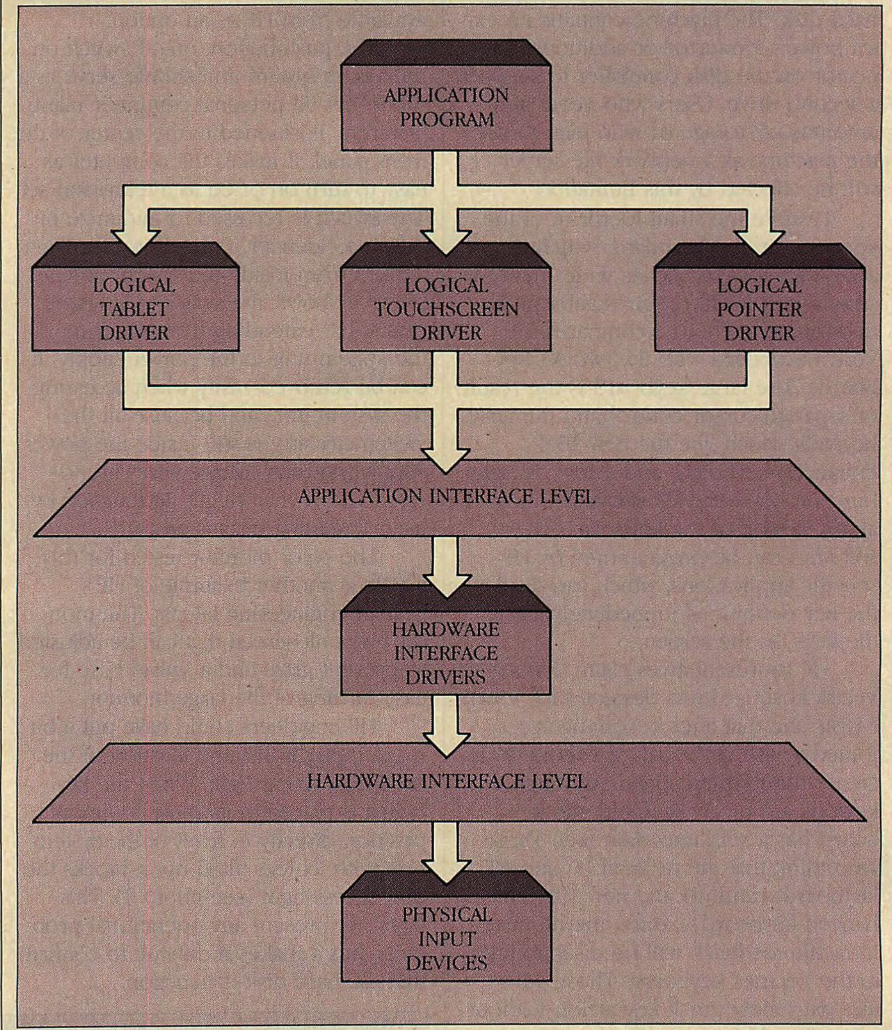
FIGURE 1: *HP-HIL Architecture*



The HP-HIL system allows an application program either to use the logical drivers that HP supplies or to use the normal device drivers that are supplied with an IBM AT. The HP-HIL interface is thus transparent to the application.

to send commands and data to them. Whenever the controller receives data from one or more of the devices, it issues an interrupt so that the CPU can process the data.

The Vectra includes a set of drivers called the *input system* to support the HP-HIL devices. The architecture of the input system is divided into two levels: application interface and hardware interface. Figure 1 shows the architecture of the input system.

At the hardware interface level, drivers respond directly to hardware interrupts and process data sent by the input devices. They manipulate that data into a standard form that is then passed to the application interface drivers.

At the application interface level, programs can communicate with the devices in a consistent manner. For example, programs communicate with the touchscreen via a logical touchscreen driver and with the graphics tablet via a logical tablet interface. Both of these logical drivers use the same code; only the data areas are different. Therefore, the application interface to the two devices is the same.

HP extensions to the BIOS provide support for all devices that use the HP-HIL. In addition, the BIOS provides an AT-compatible interface to the keyboard. The mouse interface can be achieved in two ways. The HP-HIL interface driver can be used by HP-specific programs. The BIOS also provides an AT-compatible interface comparable to the interface an application would expect to use with the Microsoft Mouse.

The touchscreen, an extra cost option, is an input device that HP has been trying to popularize for several years. With the touchscreen in effect, users simply touch the screen in different places to activate functions, make

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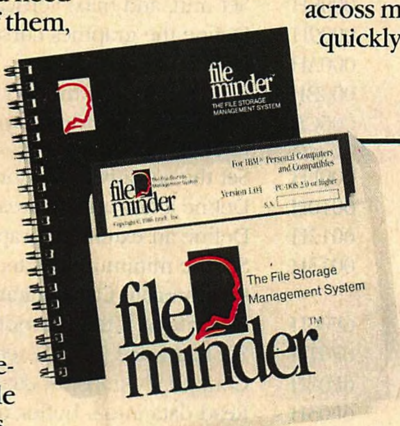

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choices, or move the cursor. Touching the screen causes an interrupt (6FH) and sends information about the location of the touch. An interrupt service routine handles the interrupt and passes the information to the logical touchscreen driver, which can scale the coordinates and invoke an application to process the information.

Interrupt 6FH is supported by the Vectra's extended BIOS. Although the HP BIOS contains all the standard BIOS functions provided by the AT (HP documentation calls this the STD-BIOS), it also contains many of the extended functions (the EX-BIOS).

To minimize possible incompatibilities with the AT, the EX-BIOS functions that deal with the touchscreen and other HP-HIL devices are all activated by a single interrupt (6FH), which is unused in the AT. The values of the AX and BP registers at the time of the interrupt determine the device for which the function is intended. Other extended functions use the same interrupts that the AT's BIOS uses, but use different function numbers. Table 1 is an overview of extra BIOS functions provided in the Vectra.

The EX-BIOS routines require a substantial data area in RAM. Instead of using locations in the standard BIOS data area (a 256-byte area that starts at absolute address 400H) and risking incompatibility, the EX-BIOS data area is located at the top of RAM. The large data area (4KB) allocated by the EX-BIOS is located where it will not interfere with programs looking for BIOS information in the same place that it is in the AT. The Vectra excludes this memory from memory recognized by DOS.

Part of this EX-BIOS data area is an extension of the interrupt vector table that contains the addresses of the EX-BIOS interrupt service routines. Programmers who write their own drivers for HP-HIL devices can place the addresses of their routines in this table.

The EX-BIOS functions and the other extended functions provided in the Vectra's BIOS are available only on the Vectra (and possibly other HP computers). Only those application programs developed specifically for the Vectra can take advantage of input devices such as the touchscreen and the graphics tablet. Although the HP mouse and keyboard are controlled via EX-BIOS functions, HP also provides standard interfaces to them. Interrupt 33H interfaces to the mouse enabling it to be accessed exactly like the Microsoft Mouse. Keyboard drivers also translate Vectra scan codes into the equivalent

TABLE 1: *Extended BIOS Functions*

INTERRUPT	AX VALUE	DESCRIPTION
10H		**Video I/O**
	6F00H	Determine whether extended functions are present.
	6F01H	Return information about primary display adapter.
	6F02H	Modify Extended Control register value in Multimode video adapter.
	6F03H	Set individual bits in the Extended Control register of the Multimode video adapter.
	6F04H	Get the current video mode and screen resolution.
	6F05H	Set the Multimode video adapter into one of 16 modes.
6FH		**EX-BIOS Functions** (More than 200 functions specifically to control HP-HIL devices and manage the HP extension to the interrupt vector table)
16H		**Keyboard Services**
	6F00H	Determine whether extended HP functions are available.
	6F01H	Return the default typematic rate and delay values.
	6F02H	Report current typematic rate and delay values.
	6F03H	Set current typematic rate and delay values.
	6F04H	Report default keyboard translator mappings.
	6F05H	Get current keyboard translator mappings.
	6F06H	Set current keyboard translator mappings.
	6F07H	Set current mappings of softkeys and cursor control pad translators.
	6F08H	Return HP-HIL identifier and address of keyboard.
	6F09H	Reset all keyboard mappings, typematic rates, and delay values to their defaults.
33H		**Industry-standard (Microsoft-compatible) Mouse Driver**
	0000H	Determine if mouse is connected to HP-HIL link.
	0001H	Increment internal cursor flag.
	0002H	Decrement cursor flag count.
	0003H	Read current mouse position and state of mouse buttons.
	0004H	Change cursor position.
	0005H	Return button press information.
	0006H	Return button release information.
	0007H	Set min. and max. horizontal positions reported.
	0008H	Set min. and max. vertical positions reported.
	0009H	Define the graphics cursor.
	000AH	Define the text cursor.
	000BH	Read the mouse motion counters.
	000CH	Define the subroutine to be called when an interrupt occurs.
	000FH	Set the sensitivity of mouse movement.
	0010H	Define a fast update area.
	0012H	Define an extended graphics cursor.
	0013H	Set the minimum distance doubling factor.
14H		**Asynchronous Communications Port**
	6F00H	Determine if the extended functions are available.
	6F01H	Set baud rate (allows setting up to 19,200 baud).
	6F02H	Continually transmit data from a buffer to the port.
	6F03H	Read data into a buffer until buffer is full or timeout occurs.
	6F04H	Read data until buffer is filled, an error or timeout occurs, or a special range of characters is read.
17H		**Parallel Printer Port**
	6F00H	Determine whether extended functions are available.
	6F02H	Transmit data as long as data are in the buffer and no error occurs.

These functions are included in the Vectra's BIOS, but are not available in the IBM AT BIOS; they can be used only by HP-specific applications. The HP-specific nature of the keyboard interface prevents standard typematic programs from running.

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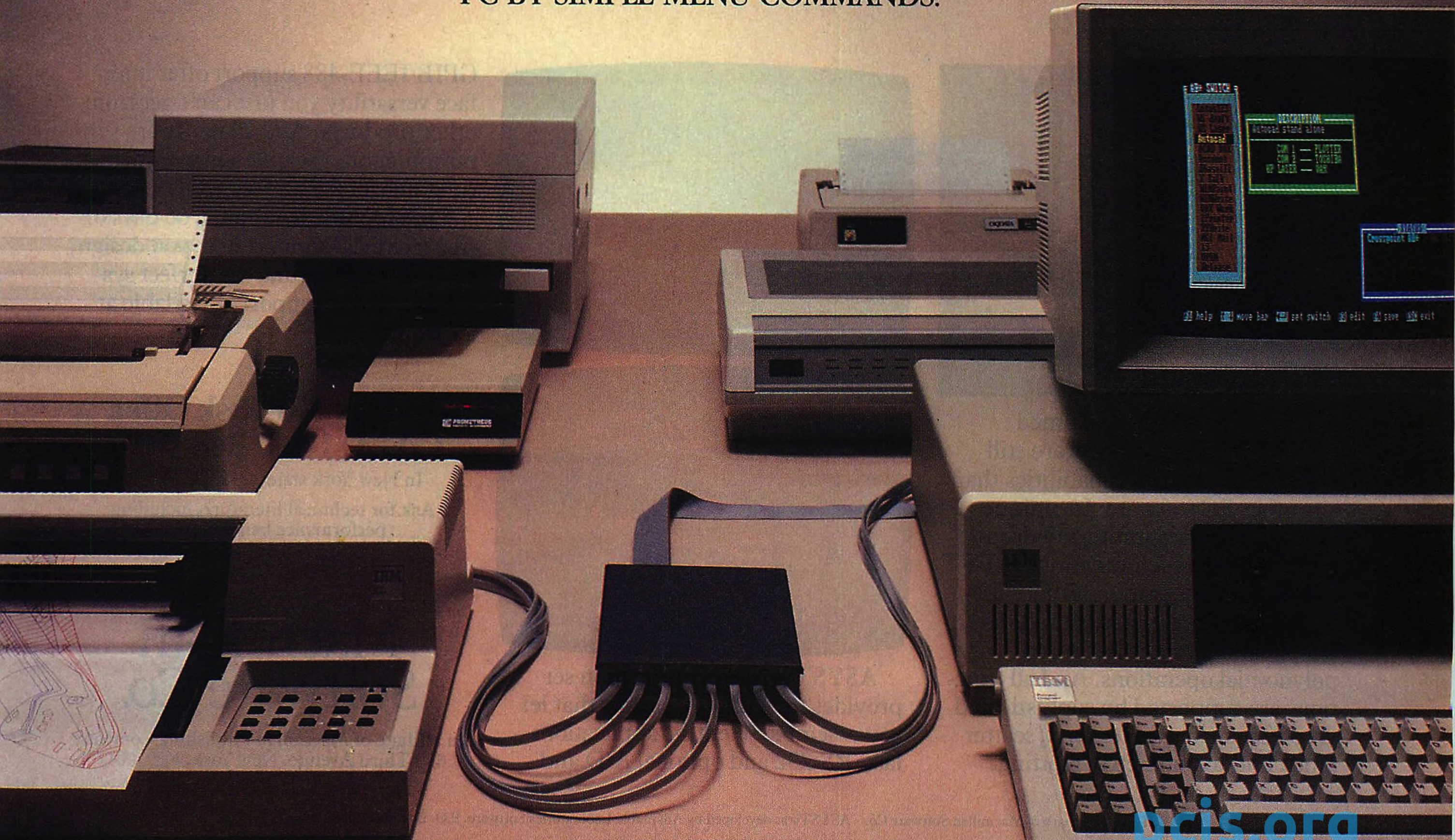

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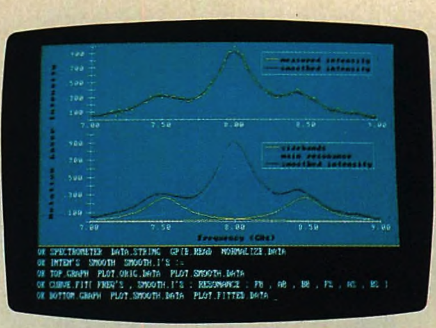

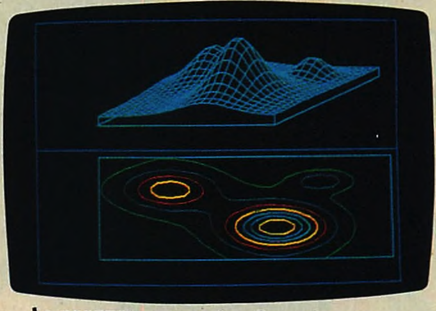

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AT scan codes and pass them on to the 8041 keyboard controller.

Another extra feature on the Vectra is the row of eight soft keys (labeled F1 through F8) across the top of the keyboard. These are in addition to the normal block of 10 AT-style function keys (F1 through F10). Controlled by EX-BIOS functions, the soft keys can be set to correspond to the first eight standard AT function keys, or they can send unique character codes to the system.

HP's Personal Application Manager makes extensive use of these soft keys. PAM is essentially a shell that allows novice computer users to start programs, get a directory listing, and perform simple functions without understanding how DOS works. PAM lets users make choices by displaying a series of labeled boxes at the bottom of the screen. Each of these boxes is positioned directly over the soft key that is used to invoke the particular function.

Other programs can also use the soft keys. As with the other nonstandard features of the Vectra, these programs must be Vectra-specific.

The HP multimode display adapter card and color display monitor provide additional features not found on the IBM color/graphics adapter (CGA) and color monitor. As with the CGA, the multimode adapter's display memory starts at address 0B8000H and is compatible with programs written for the CGA. However, it contains 32KB of memory (rather than the 16KB offered by IBM), that enable it to offer higher-resolution modes. In addition, the display memory is fully synchronized to prevent the snow or flicker problems that occur with the IBM card when writing to video memory while the refresh circuitry is active.

The character generator ROM on the multimode adapter card contains four separate 256-character sets. The different sets are used depending on the video mode and the type of monitor connected to the adapter card.

Two of the character sets consist of the 8-by-8-cell characters, the same resolution generated by the CGA. One of the character sets is equivalent to the IBM character set; the other is an HP-specific set in which character codes 0 through 1FH and 7FH through FFH designate different characters from the IBM set. Essentially, only the alphanumeric characters and punctuation characters are common in the two sets. The IBM equivalent is used by default in text mode whenever a 15-KHz (200-line) monitor is attached to the multimode adapter. The HP-specific character set is used by HP applications requiring the different characters.

The other two character sets are high-resolution; they can be used when a 25-KHz (400-line) monitor, such as the tested HP color monitor, is connected to the adapter. One of these high-resolution character sets consists of 8-by-16-cell characters that have resolution similar to that generated by the IBM monochrome adapter. These characters are used by default in text mode with the 400-line, high-resolution monitor. The other character set is HP-specific and contains characters with 8-by-14 cells. This character set is used in HP-specific video modes to generate 27 lines of text per screen (instead of the normal 25 lines).

The multimode video adapter supports all seven text and graphics modes (0 through 6) provided by the CGA. However, when text modes 2 or 3 are used and the multimode monitor is connected, the character generator sends the high-resolution 8-by-16 characters, instead of the 8-by-8 characters generated by the CGA. In text mode 3, these characters can appear in color.

Although the multimode adapter does not support video mode 7 (used by the IBM monochrome adapter), the high-resolution characters displayed in modes 2 and 3 have similar resolution. In addition, the multimode adapter can emulate the monochrome adapter by displaying underlined text.

The attribute byte associated with each character in text mode determines items such as background and foreground colors, the character intensity, and the blinking set. The HP multimode monitor follows the IBM convention of blue foreground color and black background color to indicate underlining. Because it can display characters in color as well, the multimode monitor uses another bit in the attribute byte to signal whether underlining or color should be used.

If the blinking bit in the attribute byte (bit 7) is set, and the foreground and background colors are set to blue and black respectively, the multimode adapter assumes that the character is underlined. In such a case, it displays the character as underlined but sets the foreground color to white. This means that only monochrome (white on black) characters can be underlined. If the blinking bit is not set, the character is displayed without underlining but in color (blue on black). This feature makes the multimode adapter marginally different from the CGA. The multimode adapter will not display charac-

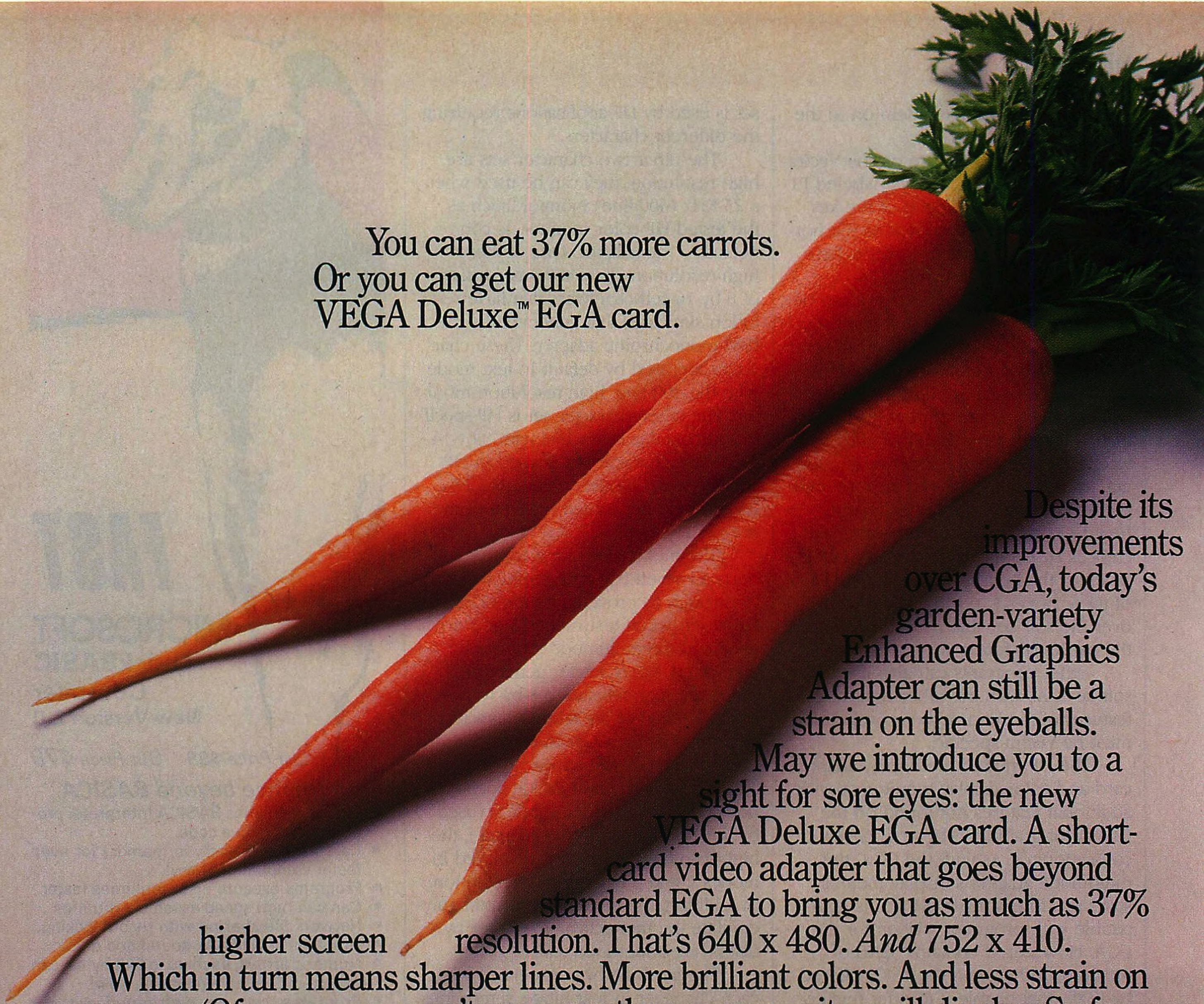

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TABLE 2: *Additional Video Modes*

HP MODE	DESCRIPTION
08H	80 character by 27 line, text mode, B&W
09H	80 character by 27 line, text mode, color
0AH	40 character by 27 line, text mode, B&W
0BH	40 character by 27 line, text mode, color
0DH	640 by 400 pixel, graphics mode, B&W
0EH	320 by 400 pixel, graphics mode, color
0FH	320 by 400 pixel, graphics mode, B&W

In addition to the seven standard video modes, the multimode adapter supports seven additional video modes that are unique to the Vectra.

ters set as blue blinking characters on black. The multimode adapter has the underlining capability of the IBM monochrome adapter and the high-resolution color text that equals the EGA's resolution and the CGA's color.

In addition to the seven standard video modes, the multimode adapter supports seven modes that are unique to Vectra (see table 2). To access these modes, a program must issue the BIOS interrupt 10H, with AX set to 6F05H and BL set to the mode number. This is a special EX-BIOS function. These modes cannot be set by the standard set video mode BIOS function interrupt 10H, (AH=0), by a MODE command, or any by other keyboard command.

EASY INSTALLATION

The cover of the unit is fastened with three screws on the rear panel. A #2 Phillips, a #2 Posidrive, or a flat-blade screwdriver can be used to remove the screws, permitting both automated assembly and easy removal by ordinary people. The wraparound designed cover lifts straight up to remove.

Photo 4 shows the inside of the system unit. The on/off switch can be removed and reinstalled in an instant, without any tools, so it does not interfere with working inside the unit.

With only a few exceptions, installing hardware in the Vectra is extremely easy, because the machine offers many user-friendly conveniences. For example, the cables attached to the disk drives all have plastic loops that extend from the connectors. Instead of prying off a connector with fingernails, a user can put a finger through the loop and pull the connector straight off.

The drives supplied by HP are all fastened to the chassis with a slide-rail mechanism that allow the user to insert and remove drives without a screwdriver (see photo 5). After disconnecting the cables, a drive is removed by pressing a button on each side of the drive enclosure and sliding the unit out. To replace the drive, slide it back in the enclosure until it clicks into place.

The slide-rail arrangement is convenient until the user wants to add third-party drives. Extra mounting gear is required to fasten drives that do not use the HP slide-rail system because the disk enclosure is wider than the enclosures used for 5¼-inch peripherals.

One area in which installation is not easy is inserting an 80287 math coprocessor chip. As photo 4 shows, the math coprocessor socket lies directly under the power supply, making access to it extremely difficult. The HP documentation recommends removing the processor extension card (the rightmost card) and the battery pack (which is wired to the processor extension but attached to the power supply) before attempting to install an 80287. Removing the power supply is also a good idea to be sure that the pins of the 80287 chip are aligned properly in the socket. Removing the power supply is not difficult—only two screws hold it in place. But disassembling the system unit should not be necessary just to install a math coprocessor.

Another potential installation problem is the 80286, which is soldered in place rather than being socketed for easy removal. As the 80386 accelerator cards make their way into the market, they will probably require removing the 80286 chip and inserting a connector from the accelerator card to the 80286 socket. With the Vectra's soldered 80286, this will be impossible.

The plastic card guide located on the inside front panel has certain limitations. When full-length cards are inserted into the computer, the edge facing the front of the system unit slides into the card guide. This not only aligns the card so that it goes into the slot properly, but also keeps the card from moving around if the unit is transported. IBM uses separate card guides

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8ZE16

for each slot; these guides are pushed into place individually when a new card is added. The Vectra uses a single plastic piece that includes a hole through which the on/off switch slides and card guides for all the expansion slots.

This one-piece card guide works well with individual cards, but it can present problems when installing piggyback cards. During an attempt to install a 4MB Intel Above Board into the Vectra, the edge of the piggyback board bumped into the card guide for the adjacent slot, thereby preventing the card from fitting properly. On an IBM computer, this problem would be resolved by simply removing the card guide from the adjacent slot; the Vectra's one-piece guide, however, prevents that solution. Throughout the tests in this article, the Above Board was used without the piggyback card.

The Vectra has seven expansion slots—two 8-bit slots and five 16-bit slots. In the unit tested, four of those slots were in use. The hard-disk controller, a 16-bit card, was inserted in the slot nearest the power supply, the serial/parallel interface card went into the 8-bit slot next to the disk controller. The two slots at the end of the system unit (an 8- and a 16-bit slot) were used by the multimode video adapter, which consists of two cards connected by a cable. No expansion card is required for the diskette controller, which is contained on the system board.

As mentioned previously, only one drive bay is available to house internal drives. This bay has room for three half-height drives or one full-height hard disk and one half-height diskette drive.

The 135-watt, 5-A power supply unit should supply adequate power to any expansion cards and peripherals installed into the system unit.

The Vectra comes equipped with MS-DOS 3.1. A few items are missing from the Vectra version of DOS, and a few additional features are included that are not available with the standard IBM DOS package.

All BASIC files are missing, including examples and the BASIC interpreter itself. Also left out are all .PIF files, VDISK, KEYBFR.COM, KEYBGR.COM, KEYBIT.COM, KEYBSP.COM, KEYBUK.COM, and SELECT.COM.

The extra files that come with the Vectra's version of DOS include CONFIG.SYS that installs HP's PAM; PAM files MANAGE.MSG, MANAGE.OVR, MNGEPAM.EXE, PAM.MSG, and PAM.OVR; KEBUS.COM, which replaces the ROM BIOS keyboard routines in order to support non-U.S. keyboards; a SETUP.COM program that is equivalent to the IBM SETUP program shipped on the IBM diagnostics disk; SETUPHP.BAT, TVHP.COM, and PDIOHP.EXT, three files that support TopView on the Vectra; FC.EXE, a standard MS-DOS program not used by IBM that compares the contents of two files; and FM.EXE, an HP file manager that allows users to perform file-management functions by using the soft keys.

PUT TO THE TEST

As with all the computers reviewed in this series, two different kinds of tests were used to check the compatibility and performance of the HP Vectra. First, the computer was checked out with a standard set of hardware and software products. Then the *PC Tech Journal* AT Evaluation Suite was run and the results were compared to an 8-MHz AT. (See "Out from the Shadow of IBM", Steven Armbrust, Ted Forgeron, and Paul Pierce, August 1986, p.53, for details on these programs.)

The add-on hardware products that were installed included the HP mouse, an Intel Above Board AT with 2MB of memory, a Microsoft bus mouse, a Hayes Smartmodem 1200B, and an IBM Enhanced Graphics Adapter and display.

The application programs tested on the Vectra were Microsoft Word and Windows to test graphics capabilities; Borland's SideKick, SuperKey, and Turbo Lightning to test memory-resident programs; Living Video Text's Ready! to test expanded memory; Hayes Smartcom II to test the communications port; and the IBM SETUP and Advanced Diagnostics programs for a general check-up. Lotus Development Corporation's Symphony was also tested.

Problems with installing the Intel Above Board were noted earlier. Even though both the modem and the EGA worked properly, operational problems occurred with the HP mouse, the Microsoft bus mouse, and Above Board.

Both the Above Board and Microsoft Mouse problems involved using Microsoft Word (one of the standard software tests). When Above Board was installed, invoking version 2.0 of Microsoft Word caused the following now-famous Microsoft copy-protection message to appear:

****Internal Security Violation****
The tree of evil bears bitter fruit,
Crime does not pay.
THE SHADOW KNOWS
Trashing program disk

This message appeared even when attempting to run Word from the origi-

nal diskettes (but the disks were not "trashed"). When Above·Board was removed, Word 2.0 ran without problems. Word 3.0 is not copy protected and running it equipped with Above Board did not cause problems.

The fact that problems exist with one copy-protected program should caution users against purchasing other copy-protected programs. Copy-protected software is apparently sensitive to the HP configuration.

Microsoft Word versions 2.0 and 3.0 and Microsoft Windows were tested with the HP mouse, the Microsoft serial mouse, and bus mouse.

When the Microsoft serial mouse was tried with the Vectra, it worked fine with Word 2.0. With Word 3.0, however, no mouse pointer appeared on the screen and no amount of effort could get the mouse to work.

Difficulties were encountered with the installation of the Microsoft bus mouse. When Microsoft's MOUSE.SYS driver (either version 5.0 or 5.02) was invoked, it did not recognize the bus mouse and displayed a message to that effect. HP customer support confirmed that a problem exists with the bus mouse. Word 2.0 and 3.0 and Windows could not be run with the bus mouse.

The HP mouse worked successfully with Word 2.0, but with 3.0 no mouse appeared. The HP mouse was inactive when it was installed with Microsoft Windows. HP supplied a patch disk to cure these problems with the HP mouse. After the patch, it worked with Word 2.0, but with 3.0 the system hung and had to be rebooted. The HP mouse still was not recognized correctly by Windows. Moving the mouse around caused the cursor to move around the screen as if the cursor keys were being used; the mouse pointer did not appear as expected.

The problems that occurred with standard applications running with both HP and add-on hardware possibly will be experienced with other third-party add-on devices.

One pleasant feature of using Word 3.0 on the Vectra is that the program takes advantage of the high-resolution graphics modes available on the multimode display adapter. This is similar to using Word with the Hercules Graphics Card in that, although the characters are limited to white on black, the underlining, boldface, and italics can all be displayed on the screen. Word can also be invoked in text mode, in which case the high-resolution text mode characters can be displayed in a choice of colors.

All the Borland products and Smartcom II ran without incident on the Vectra, and the quick check of Symphony seemed to demonstrate that it would run without problems as well. The initial version of Ready! (version 1.0) caused a "Parity check" error. Version 1.0C ran correctly.

IBM's SETUP and Advanced Diagnostics programs confirmed the differences between the AT and the Vectra. SETUP did not recognize the hard-disk drive (C:), and the IBM Advanced Diagnostics program was unable to perform a low-level format of the drive. In addition, the IBM Advanced Diagnostics returned a "Data error" message on the extended memory test, a "Replace keyboard" error message on the keyboard test, an "Error — color/graphics monitor adapter" message, and an "Error — cause undetermined" message on the hard-disk test.

The *PC Tech Journal* AT Evaluation Suite consists of five compatibility and performance tests: ATBIOS to investigate the BIOS and BIOS data areas, ATKEY to test keyboard compatibility, ATPERF to measure CPU and math co-

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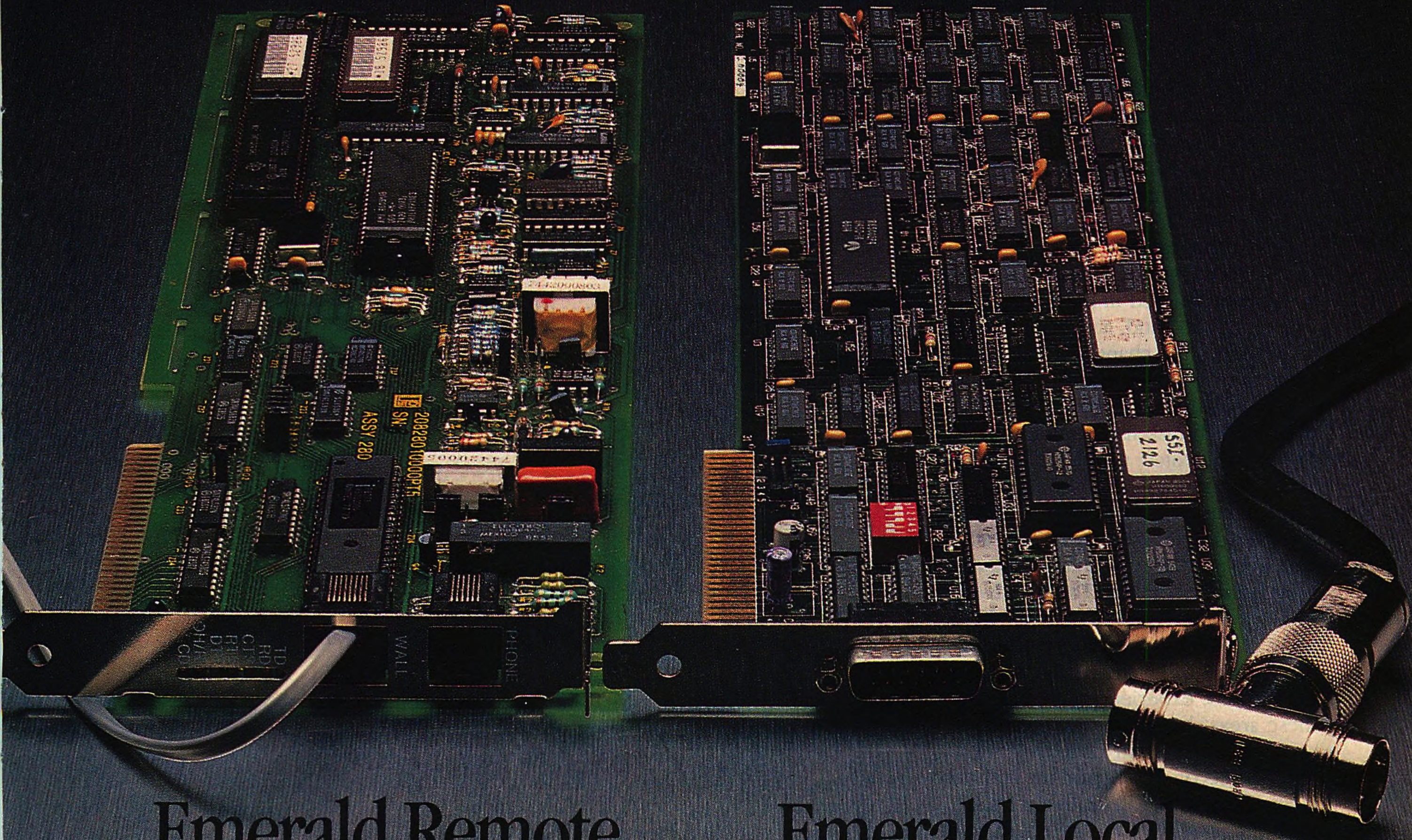

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processor clock rates and memory access times, ATFLOAT to measure floating-point operations, and ATDISK to measure hard disk performance. Table 3 lists the results of these tests.

The ATBIOS test showed that the ROM BIOS was manufactured by Phoenix Software Associates, a primary BIOS supplier for many of the IBM-compatible computers.

Even though the tested machine included 640KB of memory, ATBIOS showed only 636KB. The missing bytes are the memory used by the EX-BIOS for its data area and are located at the top of memory. When ATBIOS listed the equipment as maintained in the equipment flags byte of the ROM data area, it showed that the BIOS sets the equipment flags incorrectly concerning the presence or absence of the 80287 math coprocessor.

HP has issued a patch disk to fix this flawed version (A.01.02) of the BIOS. The patch disk contains a file called PATCH.EXE that should be invoked from the AUTOEXEC.BAT file. The patch program updates the BIOS to version A.01.02.06 and enables ATBIOS to report the status of the math coprocessor correctly. The latest ROM version now being shipped in machines is version A.01.02.04 and, according to HP, incorporates the changes in the patch program mentioned above.

In addition to the 80287 problem, the HP patch disk lists several others fixed by the patch: problems with serial ports (including COM3 and COM4); the Ungermann-Bass problem; the SNA (system network architecture) 3270 problem; and all interrupt problems that have been discovered. The details of these problems are not explained and none of them was discovered during the testing for this article. Vectra owners who are experiencing trouble in these areas should request the necessary patch from their dealers.

The second compatibility and performance test, ATKEY, measures the programmability of the keyboard by attempting to set a faster typematic rate. ATKEY was unable to run on the Vectra, because of the HP-HIL interface to the keyboard. The Vectra has its own EX-BIOS function that allows programmers to set the typematic rate and delay factor, rather than forcing them to communicate with the hardware directly. Unfortunately, typematic programs that are written for the AT normally send commands directly to the keyboard controller chip, and those programs will not run. As noted earlier, the typematic rate for the keyboard can be

TABLE 3: *Compatibility and Performance Tests*

	IBM AT with 30MB[a] disk (8-MHz model)	HP VECTRA with 20MB disk
ATBIOS		
ROM BIOS data	11/15/85	08/12/85
ATPERF		
Average RAM instruction fetch (µs)	.403 (100)[b]	.403 (100)
Average RAM read time (µs)		
BYTE	.401 (100)	.402 (100)
WORD	.401 (100)	.402 (100)
Average RAM write time (µs)		
BYTE	.401 (100)	.402 (100)
WORD	.401 (100)	.401 (100)
Average ROM read time (µs)		
BYTE	.401 (100)	.401 (100)
WORD	.401 (100)	.401 (100)
Average video write time (µs) (CGA only)		
BYTE	1.208 (100)	1.148 (105)
WORD	2.415 (100)	2.416 (100)
Average EMM write time (µs)		
BYTE	.402 (100)	.402 (100)
WORD	.402 (100)	.402 (100)
Average EMM read time (µs)		
BYTE	.402 (100)	.402 (100)
WORD	.402 (100)	.402 (100)
CPU clock rate (MHz)	8.0 (100)	8.0 (100)
Math coprocessor clock rate (MHz)	5.3 (100)	5.3 (100)
Refresh overhead (%)	7.1	7.1
RAM read wait states	1	1
RAM write wait states	1	1
ROM read wait states	1	1
Video write wait states (CGA)	8	7
EMM read wait states	1	1
EMM write wait states	1	1
ATFLOAT		
Performance as percentage relative to AT	100	100
ATDISK		
Sectors/track	17	17
Heads	5	4
Cylinders	731	605
Total space (million bytes)	31.81	21.06
Track-track seek time (ms)	23.7	9.9
Average seek time (ms)	37.1	93.4
Effective transfer rate (KB/sec)	170.1	170.1
DOS file I/O (sec)	7.3	10.8
Interleave	3	3

[a] *The figures for the IBM AT are the average results from several machines, whereas the results from the HP Vectra are taken only from the review sample model.*
[b] *Figures shown in parentheses represent the relative performance expressed as a percentage compared to* PC Tech Journal's *baseline machine, the 8-MHz, 30MB AT.*

The performance of the HP Vectra is comparable with the IBM AT for ATPERF and ATFLOAT. The only variation is in the average video write time for a byte. The hard-disk performance is comparable with that of the XT rather than the AT.

changed by using one of the EX-BIOS functions of the HP Vectra.

ATPERF shows that the performance of the CPU, math coprocessor and memory access is up to the standard set by the 8-MHz AT. The Vectra uses an 8-MHz 80286, and its math coprocessor runs at the full 5.3-MHz. In all cases, the Vectra achieved the same relative performance (100 percent) as the AT. The only significant difference discovered by ATPERF was in the number of wait states required for writing to video memory. The Vectra's multimode adapter exhibited better performance than the CGA, requiring only seven wait states, as compared to eight for the CGA running on an AT.

ATFLOAT also confirmed an equivalent performance level for the Vectra. This test showed that the Vectra can process floating-point operations at the same speed as the AT.

The Vectra's weak spot, a slow hard disk, was uncovered by ATDISK. As table 3 shows, the track-to-track seek time for the Vectra's 20MB disk is almost four times slower than the AT's, and the average seek time is almost three times slower. These figures are more in line with the slower XT hard disks than the higher-performance disks found on the AT. The DOS file I/O test also shows results that correspond more closely to an XT hard disk than to the AT disk.

The Vectra tested by ATDISK included HP's 20MB half-height drive. A 40MB drive is also offered. The 40MB drive was not available for testing, so its performance was not measured.

HARD TO DISLIKE

HP's attention to human factors in the design of Vectra is evident in its printed documentation as well. The HP documentation is one of the finest sets (if not *the* finest) in the industry. The standard documentation set consists of an installation guide filled with helpful pictures, a user's guide, and a DOS reference. All of these books are cleanly laid out, well organized, and clearly written. In addition, HP encloses a 17-by-32-inch instruction sheet that describes in 11 steps how to install the most common internal options, such as memory chips, the math coprocessor chip, expansion cards, and disk drives. For many people, this one sheet includes all the installation instructions they will ever need to use.

The optional programming documentation maintains a similar high standard of quality. Both the two-volume technical reference (one volume covers the hardware, the other covers the BIOS) and the DOS programmer's reference contain extremely complex material that is presented with clarity.

A review of an HP product would not be complete without a mention of HP's Customer Response Center and telephone support. Calls are handled quickly, courteously, and professionally. When bugs are reported, HP representatives are open about the problems, sharing similar problems they have encountered. The company is also quick to incorporate fixes in patch disks that are available through HP dealers.

Although HP provides a toll-free number to the Customer Response Center, this phone support is not without cost. For $45 each, HP issues HelpLine certificates that entitle the bearer to one-time telephone assistance. Representatives will not answer questions until a certificate number is given. With this HelpLine service, HP guarantees engineer assistance by telephone within two hours of a call and provides all follow-up support at no extra charge.

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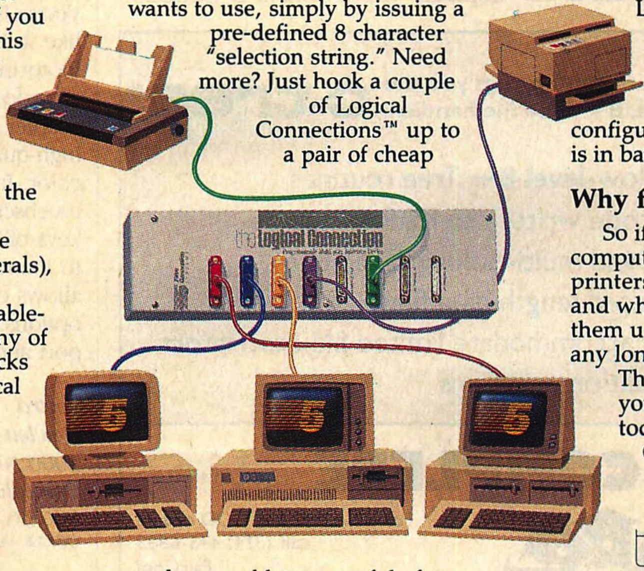

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Vectra with their other HP equipment, this can be an ideal AT-compatible computer. Customers who buy all of their add-on equipment from HP and who use application programs verified by HP can reap the benefits of the Vectra's easy-to-install disk drives and the extra features such as the touchscreen, multimode adapter, and soft keys.

However, those who are looking for a pure AT alternative should carefully test the applications they plan to use before purchasing the machine. The incompatibilities noted in this article (problems with the Intel Above Board, Microsoft Mouse, Microsoft Word, and the IBM SETUP and Advanced Diagnostics programs) may not be the only ones lurking inside the Vectra. And even though HP has shown extreme willingness to provide patches and workarounds, some delays are inevitable when problems occur.

In addition, the Vectra's 20MB hard disk is not the high-performance drive used in the AT. Its performance is comparable to the slower drive in the XT. Adding a higher-performance third-party drive can be a chore because of the Vectra's slide-rail mounting system. If the third-party drive does not contain the slide rails, extra mounting gear will need to be constructed. Also, because the Vectra's hard-disk controller is not included with the base system, users who add their own drive will need to purchase a separate controller.

Despite these drawbacks, the Vectra is a computer that is hard to dislike. It is attractively styled, with a small footprint that makes it better suited for crowded desktops. Its multimode video adapter and monitor produce crisp high-quality text in monochrome and color. Its other extra features, such as touchscreen, HP-HIL interface, and soft keys offer innovative ways for the user to interact with this machine. Its design allows easy installation of most internal options. HP also offers top-quality support and first-rate manuals.

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Steven Armbrust, a freelance technical writer, and Ted Forgeron, software project manager for Intel Scientific Computers, will be reviewing several AT-compatible computers for this series. Together, they are the authors of the Programmer's Reference Manual for IBM Personal Computers *to be published by Dow-Jones Irwin in late 1986.*

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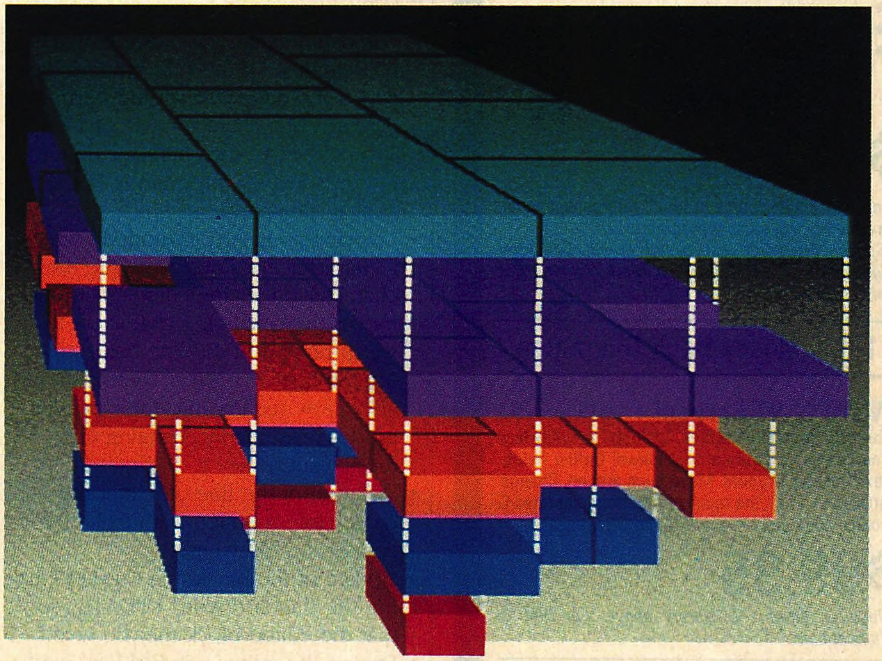


COMPUTER GRAPHIC • GARY ZAMCHICK/ DADABASE DESIGN

Solving programming problems by breaking them down into smaller problems (and further into low-level functions) is a proven technique. Although most languages do something to aid this process, FORTH encourages an approach in which the organic nature of this solution is more apparent. After a general plan is discovered, smaller problems can be examined one by one and changes can be made. Often the nature of the overall problem is restated as a result of discoveries made during testing. In addition, experimentation with different means of factoring a problem is practical in FORTH because each word definition is so easily tested and altered. In this, the second in a series of articles on FORTH (see "FORTH," Mahlon G. Kelly and Nicholas Spies, September 1986, p. 48), the authors discuss programming methods. A final article in a future issue will evaluate current FORTH implementations.

Writing a FORTH program entails developing a series of short definitions, using them in other definitions, and finally putting them all together, usually in one or more words that execute the program or portions of it. Ideally, each word defined is a clear solution to a small problem. As programming continues, the problems become more and more generalized, until the entire program can be stated in just a few words. In this sense, a FORTH program is a hierarchy of solutions that document the thought processes of the programmer. The FORTH environment, therefore, is both a programming language and a test bench for problem solving.

The advantages of FORTH are considered here relative to an actual design. The program developed is a FORTH program editor (useful because some implementations come without a built-in, full-screen editor). For maximum utility, the editor is designed to work with both DOS-based dialects and native FORTHs that accept source code in blocks (a native FORTH supplies its own operating system.)

The FORTH standards specify that programs be written in blocks (1KB segments of ASCII characters). A block is simply 1,024 printable characters (arranged as 16 rows of 64 characters) with no carriage returns or other control characters. (Blocks are discussed in more detail in the program design.) In a native FORTH, all disk storage is mapped into blocks; in a DOS-based FORTH, blocks are stored in files.

[Note that FORTH uses punctuation symbols as commands. By convention, additional spacing is placed before and after all FORTH words throughout this article where it is necessary to separate the actual FORTH word from normal punctuation.—WF]

Generally, a FORTH editor is invoked with **n EDIT** , which displays the contents of block **n** and allows the contents to be modified and saved back to disk. Because the program here is a

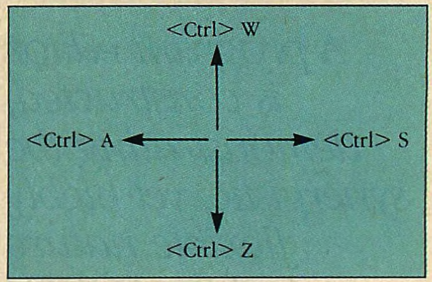
screen editor, text can be changed by moving the cursor in any direction and entering, inserting, or deleting characters at the cursor position; it also should allow copying, replacing, inserting, and deleting lines of text.

The editor must attempt portability among all FORTH dialects available for the PC, both DOS-based and native, and, as an extension, it must be easily customized to work with different video adapters. (For complete portability, the editor should be configurable for operation even on terminals that offer no absolute cursor positioning commands.) The program design should permit:

- Editing a block by invoking the word EDIT, displaying the contents of the block in 16 lines of 64 characters each, and placing the cursor in the upper left corner of the screen.
- Cursor movement left, right, up, and down (see figure 1) using Ctrl-key combinations. The requirement of compatibility among native FORTHs prevents use of the PC's numeric key pad. The editor also should permit deletion of a character (via Ctrl-key).
- Typing over of the character under the cursor if the program is in the appropriate mode.
- Entering an insertion mode in which a character does not overwrite the character under the cursor, but first moves the remaining characters toward the end of the line before placing the new character. Then it should also allow reentry into the typeover mode (presumably changing the mode via Ctrl-key.)
- Deletion of the line of text at the cursor into a buffer (via Ctrl-key) for reinsertion elsewhere.
- Update of the block (via Ctrl-key), using the standard word UPDATE , so that the edited block may be saved.
- Exiting the editor (via Ctrl-key), with reentry into the FORTH interpreter.

The most important task in translating these goals into FORTH words (and implementations) is a good program design, which begins with giving structure to the smaller problems within the problem. In this case, because flow charts can be difficult to extend or refine, a verbal description of the editor's functions (as shown in figure 2) is a better choice. Indeed, a very strong parallel is apparent between this figure and the structure of the word that performs the principal work of the editor (see the EDITCASE function, discussed later in this article). In a very real sense, the general specification in figure 2 is a program waiting for a language. The programming process consists of

FIGURE 1: *Cursor Movement*



Cursor movement in the program editor must be accomplished using Ctrl-key sequences instead of the numeric pad keys. This inconvenience is an expense of portability: some native FORTHs return different numeric pad scan codes than those used by DOS.

modifying FORTH by adding words to it so that the specification will run.

The design approach thus far has been top-down, but the actual program is better written from the opposite end. FORTH code is compiled from the bottom up: FORTH primitives are used to build low-level program words, that are used to define intermediate-level words, and so on, until the highest level word, in this case, EDIT , is defined. The low-level words are tested as they are written, and as intermediate-level words are defined, more low-level words are produced as needed. The ease with which low-level words are defined is a powerful inducement to begin a program by building a foundation.

Thus, programming in FORTH proceeds simultaneously from top down and bottom up. A top-down perspective keeps the program goals in focus, while the bottom-up approach concentrates on building a set of executable utilities that eventually implement the design objectives, perhaps adding valuable functions along the way. Creating code from the bottom up often abets the design process itself. Strict top-down programming involves only decomposing problems to predefined functions, whereas by building functions from the bottom up, FORTH encourages the creation of a vocabulary better suited to solving a specific problem. This, in turn, encourages the formulation, or reformulation, of the top-down goals.

USING MEMORY

The program editor provides a good example of how computer resources are allocated in a FORTH application. In FORTH, block buffers are the mass-storage I/O medium; it would be possible just to display a block buffer, alter its contents, and save the result to disk.

FIGURE 2: *Program Editor Specification*

Load the block to be edited into a block buffer.
Display the block, placing cursor in upper left.
Begin a loop.

Get a character from the keyboard.
Is it a control character?

If so, execute an editing command.
If not, is the character printable?

If so, is editor in insert mode?

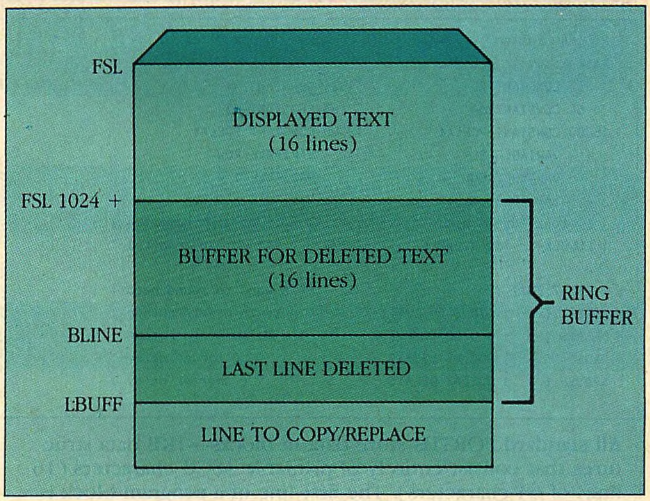
If so, insert character.
If not, replace character.

If not, discard unprintable character.

Loop until exit command is received.

FORTH program design often begins with an outline that is translated almost directly into code (the function produced to implement this outline is EDITCODE in figure 9). The FORTH programmer builds a large toolbox of functions, testing each low-level function thoroughly before proceeding.

FIGURE 3: *Buffer Arrangement in the Editor*



The ring buffer lets a user undo line deletions—this is an advanced facility that was simple to program. The buffer for deleted text has a capacity large enough to hold the text from an entire source code block; the user can delete all the lines in a block and later restore them undamaged.

But this does not allow for any "undoing" of changes, short of reloading the original block from disk.

Instead, the buffer is copied into the scratch pad area of memory, the address of which is put on the stack by PAD Changes are made, then the edit buffer is copied back to the block buffer (see figure 3). The buffer could be saved back to disk on command. This use of memory provides more flexibility in saving changes and produces other important repercussions as well.

(The EDITBLK program, developed below, is written in FORTH-83, and many standard FORTH-83 words are discussed. See the sidebar "Building on FORTH Standards" with the September article, p. 60, for an explanation of the standards. For additional information on the standards, a FORTH-83 manual should be consulted.)

The FORTH word **n BLOCK** moves block **n** into a block buffer, from which 1,024 characters are moved with CMOVE to FSL (*first screen location*, the beginning of the editor's displayed text buffer), where they will be displayed and changed as they are edited. When the UPDATE command is executed, the 1,024 characters after FSL are moved back to the block buffer using CMOVE . FORTH automatically saves the block buffer to disk. The cursor position on the display and its effective position in the edit buffer above FSL will have to be kept in step. Its position will be stored in two variables specifying the row and column offsets from the upper left corner of the terminal display.

These offsets then could be used to calculate all other information needed about the cursor position.

One feature the editor requires is the ability to insert and delete a line of text at the cursor. However, because of the way memory has been allocated, *any* number of lines may be deleted or inserted, without fear that a line will be lost. The memory after the last displayed line (starting at FSL plus 1,024) could be used to hold a determined number of deleted lines that can be inserted back into the displayed text. It is reasonable to allow 16 lines in this hidden buffer so that the contents of an entire block could be deleted and inserted elsewhere. If the insert and delete line functions were designed to work in a circular manner, then no lines would be lost. Because the displayed buffer and hidden buffer are adjoining, the code required for this circular or *ring* buffer would be fairly small. (The action of the ring buffer is explained in more detail later.)

To make the program editor as portable as possible, only two terminal commands are used: clear the screen and put the cursor on a specified row and column. Thus, the editor can be customized to work on almost any computer or terminal with very little effort. Also, the minimum required screen size of the terminal would be 16 lines by 64 columns. A user should be able to use any FORTH dialect for the PC to modify the editor using dialect-dependent words to control the PC's screen functions.

LOW-LEVEL FUNCTIONS

In examining the blocks of source code, the relationship between their design and the problem-solving process becomes evident. Block 1 of the program editor establishes constants, variables, a flag, some buffer addresses, and the basic cursor control and terminal control words (see figure 4).

The variables ROW and COL (the cursor row and column positions) and I/R (the input/replace mode flag) actually were the first of these words to be defined; the others were added later, as needed. Further along in the programming effort, often-used values (such as BL , 1K , and 64) were made constants to save memory (recall from the first FORTH article that numbers included directly in colon definitions are compiled with LIT , which puts them on the stack when the word executes).

PDELAY and SDELAY were added for two delay loops used during the display of prompts. They were made constants so that delay times can be changed without having to search the source code. SCR , which holds the most recently listed block, is already defined in some dialects. If SCR is defined in the dialect in use, delete the SCR definition to save memory. Constants and variables generally are collected at the top of a program (or at the start of the sections of a large program) to facilitate finding and changing them.

FORTH adheres to certain conventions for generating readable source code. The first line of each program block identifies the program and the

FIGURE 4: *A FORTH Block*

```
( Program Editor                         Block 01 of 10    )
: TASK ;        DECIMAL
    32 CONSTANT BL                   1024 CONSTANT 1K
    64 CONSTANT 64                     63 CONSTANT 63
  15000 CONSTANT PDELAY             10000 CONSTANT SDELAY
       VARIABLE SCR                      VARIABLE ROW
       VARIABLE COL                      VARIABLE I/R
       VARIABLE LOWBLK                   VARIABLE HIGHBLK
   ( store lowest and highest block to edit on your computer )
  1 LOWBLK !  169 HIGHBLK !    -1 I/R ! ( *** set to insert )
  \
: ----  7 EMIT ;                            ( A word to sound beep )
: MODE   ( -- ) I/R @ 0= I/R ! ;       ( select insert/replace )
: DELAYS ( n -- ) 0 DO LOOP ;              ( delays for n loops )
: PAUSE  ( -- ) PDELAY DELAYS ;                  ( longer delay )
: SPAUSE ( -- ) SDELAY DELAYS ;                 ( shorter delay )
```

All standard FORTHs store data in blocks—1KB data structures that consist entirely of printable ASCII characters (16 lines of 64 characters). The first line of a program block is always an index line that identifies the remaining 15.

FIGURE 5: *Low-level Words*

```
( Program Editor                         Block 02 of 10    )
: PADDR ( n -- )    CREATE ,  DOES>  @ PAD + 64 + ;
  1K 2 *        PADDR BLINE ( last line ) 0 PADDR FSL  ( first )
  1K 2 * 64 +  PADDR LBUFF        ( address copy/replace line )
: CONTROL ( c -- ) CREATE DEPTH DUP C, 0 DO DEPTH ROLL C, LOOP
  DOES> DUP DUP C@ + SWAP DO I 1+ C@ EMIT LOOP ;
( 27 42 CONTROL <CLR>   ( clear screen, cursor to upper left  )
( : <CXY> 27 EMIT 61 EMIT ROW @ 32 + EMIT COL @ 32 + EMIT ;   )
(          Position cursor on line X column Y                )
  : <CLR> CLEARSCREEN ;   : <CXY> COL @ ROW @ GOTOXY ;
( To use following definition of <CXY>, <HMC>, <DLF>,         )
(      and <ADV> must be defined here. Use only if terminal    )
(      has no direct cursor positioning.                       )
(    28 CONTROL <HMC>    ( move terminal cursor to upper left )
( : <CXY> <HMC>  ROW @ ?DUP IF 0 DO <DLF> LOOP THEN            )
(                COL @ ?DUP IF 0 DO <ADV> LOOP THEN ;          )
```

The FORTH code above sets up the buffer scheme begun in figure 3. Comments show how to adapt cursor control to any kind of terminal, a facility that is often necessary when editing code on a target system by means of a serial port.

block number within the program. (The operating system of a native FORTH does not keep track of this information.) Because the first line is within parentheses, it is a comment ignored during FORTH compilation. One vital type of comment is the *stack chart*, a short comment in each function definition that displays the stack's contents before and after word execution. The stack chart for DELAYS , for example, is (n —) , which means DELAYS expects to find a number on the stack that it removes during execution. Although other numbers may be on the stack when DELAYS executes, only the parameters used or created by the word need to be shown. Because all FORTH parameters are passed on the stack without implicit parameter checking, it becomes most important that the stack chart document a word's parameters.

LOWBLK and HIGHBLK were added to prevent the editor from accessing blocks it should not. A small value of HIGHBLK was specified here; a user who has more disk space available can modify the program or store a new value in the HIGHBLK variable after the editor has been loaded.

The beeper word, ---- (named to stand out visually in the source code), permits the use of unassigned Ctrl-key commands in the execution vector KEYVECTORS (introduced later). The beeper word was defined when the definition of KEYVECTORS required it, but it is a low-level word. This is one of many instances in which the top-down/bottom-up approach was especially helpful; new words were introduced easily as they were needed.

Each time MODE is used it changes the value in I/R from true to false or false to true. MODE acts as a toggle to select insert or overtype mode. (A visible mode indicator would be a useful addition to this program.)

PAUSE and SPAUSE were defined as separate words so that less space would be used in a later block. These words demonstrate that factoring out a word, DELAYS , saves some repetitive code. These loops also were defined later in the development process and moved forward in the source code.

The fundamental words continue in the next block (see figure 5). The defining word PADDR (pad address) is used to create three words that return addresses needed by the editor's buffers. PADDR simply compiles a number using the word , . The child words FSL , BLINE , and LBUFF calculate the addresses in the buffer as offsets above PAD . The addresses must be calculated

FIGURE 6: *Cursor Control*

```
( Program Editor                          Block 03 of 10      )
: @CURSOR ( -- r c ) ROW @ COL @ ;     ( recall row and column )
: !CURSOR ( r c -- ) COL ! ROW ! ;      ( store row and column )

: <SOL>       0 COL ! <CXY> ;   ( move cursor to start of line )
: <HOM>  0 0 !CURSOR <CXY> ;       ( move cursor to upper left )
: BABOVE ( -- n ) ROW @ 64 * ;  ( #bytes in rows above cursor )
: BBELOW ( -- n ) 16 ROW @ - 64 * 1K + ; ( bytes below cursor )
: OFFSET ( -- n ) BABOVE COL @ + ;  ( #bytes cursor into buff )

: CPOS   ( -- addr ) FSL OFFSET + ;             ( cursor address )
: LSTART ( -- addr ) FSL BABOVE + ;          ( start-line address)
: LEND   ( -- addr ) LSTART 63  + ;            ( end-line address)

: BLEFT ( -- n ) LEND CPOS - ;              ( bytes left in line )
```

```
( Program Editor                          Block 04 of 10     )
: LEFT   COL @  0 > IF -1 COL +! <CXY>  ( or <BSP> )  THEN ;
: RIGHT  COL @ 63 < IF  1 COL +! <CXY>  ( or <ADV> )  THEN ;
: UP     ROW @  0 > IF -1 ROW +! <CXY>  ( or <ULF> )  THEN ;
: DOWN   ROW @ 15 < IF  1 ROW +! <CXY>  ( or <DLF> )  THEN ;
: <EEL> ( -- ) BLEFT SPACES <CXY> ;        ( erase to end line )
: NEWLINE ( -- ) <SOL> DOWN ;        ( cursor, start next line )
: SHOWLINES ( -- ) @CURSOR 16 ROW @             ( display lines )
  DO I ROW ! <SOL> LSTART 64 -TRAILING TYPE <EEL>
  LOOP !CURSOR <CXY> ;
: SHOWBLK ( -- ) @CURSOR <HOM> SHOWLINES !CURSOR <CXY> ;
: TYPELINE ( -- )  CPOS  BLEFT 1+ OVER OVER TYPE
  -TRAILING  SWAP DROP BLEFT 1+ - SPACES <CXY> ;
```

The words in block 3 locate the cursor position within the displayed buffer. The words in block 4 define cursor movements and retype characters to the end of the line (with TYPELINE) and to the end of the block (with SHOWBLK).

each time the program is run because the location of PAD may change if words are added to the dictionary between editing sessions. The phrases **1K 2 * and 1K 2 * 64 +** are used to calculate the values 2,048 and 2,112 because they are easier to understand in terms of blocks and lines, and give a better idea of the structure of the edit buffer. Because the offset calculations are not in a colon definition, they are calculated only once (during compilation) and do not slow execution.

The definitions in figure 5 use the PC/FORTH words CLEARSCREEN and GOTOXY, although the comments explain how to customize cursor control for an unusual terminal, whatever the character sequences. CONTROL is a defining word, created to define words that EMIT (output) control codes and escape sequences. It will take any number of arguments from the stack, compile them into the body of its child word, and, when the child executes, output the series of bytes using EMIT. For example, if a terminal required the escape sequence ESC * to clear the screen, <CLR> (clear screen) could be defined as **27 42 CONTROL <CLR>**. Although CONTROL has an involved definition, it makes each terminal control word easier to define and more readable in the source code. The colon definition **: <CRL> 27 EMIT 42 EMIT ;** also would work, but using CONTROL saves memory after a few definitions because the execution portion (the code that follows DOES>) is shared by every word that CONTROL creates. (All words related to terminal functions are named with angle brackets to emphasize them visually.)

<CLR> and <CXY> (which positions the cursor to a specified row *x* and column *y*) may be replaced by implementation-dependent definitions to make the program execute faster. The commented definition of <CXY> is slower and relies on <DLF> (downward line feed) and <ADV> (advance the cursor), which in turn could be defined using CONTROL; this version of <CXY> would be used only if the terminal allowed very primitive control of the cursor. Other such substitutions could be made as well. For example, clearing from the cursor column to the end of a line is a capability offered by many FORTH implementations. Note, however, that only one definition of each word such as <CXY> and <CLR> is needed. For the sake of readability, all words defined with CONTROL should be grouped directly under the definition of CONTROL itself.

Block 3 continues defining words that control the cursor (see figure 6). @CURSOR (fetch cursor) and !CURSOR (store cursor) were created when it became obvious that the phrases they represent cropped up in several places as the source code was developed. They usually are paired in the same word when they are used, and they enhance

readability. By keeping the cursor position in row/column form (rather than only as a byte offset), both cursor movement and the definition of some later words is simplified.

The words <SOL> (start line) and <HOM> (home cursor) might be defined using CONTROL (for terminals that support these functions) and used instead of <CXY> in subsequent definitions. Notice that the cursor location must be maintained in two places: its actual position is stored in ROW and COL, but the terminal cursor also must be placed in the appropriate position on the screen using <CXY> .

BABOVE (bytes above) and BBELOW (bytes below), defined for use later in the program, calculate the number of bytes (in the buffer) in the rows above the cursor position and in the cursor row and the rows below it, respectively (including the entire ring buffer). OFFSET returns the number of bytes the cursor is offset from the home position (upper-left corner). Since it is used only in CPOS (cursor position), OFFSET is superfluous, except that it makes the definition of CPOS easier to understand. If speed is not an issue, words should be factored to make them as readable as possible. Note, however, that any change in the values in either ROW or COL will alter the value returned by OFFSET (and CPOS).

CPOS , LSTART (line start), and LEND (line end) return three addresses in the buffer that are needed throughout the remainder of the editor. BLEFT (bytes left) is needed for subsequent words that must know the number of bytes (characters) between the cursor and the end of the line.

The cursor position in the buffer has been located in several ways: by row and column, by the number of bytes above and below it in the PAD buffer, by the address of the start and end of the line it is in, and by the number of bytes remaining in that line. Blocks 1 through 3 thus provide a base upon which the higher-level words in block 4 are written (also in figure 6).

Basic to the editor is an ability to move the cursor in four directions without going off the display. The words <BSP> , <ADV> , and so on should be defined using CONTROL when the terminal so permits, and then used in place of <CXY> in subsequent words. Notice that ROW and COL must be updated to keep the location of the cursor in the edit buffer in step. <EEL> (erase end line) also is decidedly faster when defined using CONTROL.

NEWLINE is assigned to the Enter key (which produces the same control character as Ctrl-M) to put the cursor at the start of the next line. This word simulates the carriage-return-plus-line-feed action of Enter. However, in the editor, Enter moves only the cursor; it must not be allowed to scroll the screen. (Nor does it insert ASCII CR or LF characters. The white space in FORTH source code blocks consists only of spaces, which are recognized by INTERPRET as delimiters.)

The word SHOWLINES displays the line that the cursor is in and all subsequent lines to the end of the block. When only the lower part of the screen is changed, this word saves time over rewriting the entire screen. SHOWBLK uses SHOWLINES to display the entire block after moving the cursor to the upper left corner. @CURSOR and !CURSOR are used in tandem to put the initial position of the cursor on the stack, and to then restore it when the word is completed.

TYPELINE types all of the characters from the cursor position to the end of the line. The action of –TRAILING ,

FIGURE 7: *Intermediate-level Words*

```
( Program Editor                            Block 05 of 10      )

: BCLEAR ( -- ) FSL 1K + 1152 BL FILL ;          ( clear buffer )
: SCLEAR ( -- ) FSL 1K BL FILL SHOWBLK ;         ( clear screen )


: LOADBLK ( -- ) SCR @ BLOCK FSL 1K CMOVE ;        ( load block )
: RESTORE  ( -- ) LOADBLK SHOWBLK ;

: <UPDATE> ( -- ) FSL SCR @ BLOCK 1K CMOVE UPDATE ;  ( update )

: +BLK ( -- ) SCR @ HIGHBLK @ < IF  1 SCR +! RESTORE THEN ;
: -BLK ( -- ) SCR @ LOWBLK  @ > IF -1 SCR +! RESTORE THEN ;

: CLRTOP   ( -- r c ) @CURSOR <HOM> <EEL> ;
: WRITETOP ( r c -- ) <HOM> TYPELINE !CURSOR <CXY> ;
```

```
( Program Editor                            Block 06 of 10      )
: ?BLK# ( -- ) CLRTOP  ." * * * BLOCK#: " SCR @ .     ( block# )
  PAUSE WRITETOP ;
: UPDATES ( -- ) <UPDATE>        ( update block and show this )
  CLRTOP ." * * * UPDATED Block#: " SCR @ . SPAUSE WRITETOP ;

: ASCII ( -- n ) BL WORD 1+ C@ STATE @
  IF [COMPILE] LITERAL THEN ;  IMMEDIATE
: ?CLEAR ( -- ) CLRTOP  ." * * * X-OUT: (B)uffer, (S)creen ? "
  KEY DUP ASCII B =
  IF  DROP BCLEAR WRITETOP            ELSE ASCII S =
  IF  SCLEAR !CURSOR <CXY>            ELSE WRITETOP THEN THEN ;
: ?EXIT  ( f -- f' ) CLRTOP  ." * * * EXIT: (S)ave, (Q)uit ? "
  KEY DUP ASCII S =
  IF  DROP DROP DROP UPDATE FLUSH  1+ ELSE ASCII Q =
  IF  DROP DROP      EMPTY-BUFFERS 1+ ELSE WRITETOP THEN THEN ;
```

```
( Program Editor                            Block 07 of 10      )
: ENDCLEAR? ( -- f ) LEND C@ BL = ;
: OPENUP ( -- )       ( open text at cursor position in buffer )
  COL @ 64 < ENDCLEAR? AND IF
  CPOS DUP 1+ BLEFT  CMOVE> BL CPOS C! THEN ;
: OPEN ( -- ) OPENUP TYPELINE ;          ( open text at cursor )
: TRUNC ( -- ) <EEL> CPOS BLEFT BL FILL ;     ( truncate line )
: OVERTYPE ( char -- ) COL @ 64 <    ( replace char at cursor )
  IF  DUP EMIT CPOS C!  1 COL +!  ELSE  DROP  THEN ;
: INSERT ( char -- ) OPENUP ENDCLEAR? ( insert char )
  IF  OVERTYPE ELSE DROP THEN TYPELINE ;
: DELETE ( -- ) COL @ 64 <                       ( delete char )
  IF CPOS 1+ CPOS BLEFT CMOVE
     BL LEND C! <EEL> TYPELINE
  THEN ;
: HACK ( -- ) COL @ 0> IF  LEFT  THEN DELETE ;
```

```
( Program Editor                            Block 08 of 10      )
: CLINE ( -- ) LSTART LBUFF  64 CMOVE ; ( copy line to buffer )

: PLINE ( -- ) LBUFF  LSTART 64 CMOVE  ( put line from buffer )
  @CURSOR <SOL> TYPELINE !CURSOR <CXY> ;

: KLINE ( -- )                ( kill line into circular buffer )
  LSTART BLINE 64 CMOVE                     ( move current line )
  LSTART 64 + LSTART BBELOW CMOVE             ( move buffer up )
  SHOWLINES ;                           ( display changed lines )

: ILINE ( -- )              ( insert line from circular buffer )
  LSTART DUP 64 + BBELOW            CMOVE>      ( move buffer )
  BLINE LSTART 64 CMOVE         ( move line from bottom buffer )
  SHOWLINES ;                           ( display changed lines )
```

A FORTH project is complete when the top-down and bottom-up programming efforts come together. The blocks above complete the task of building the program editor with words to load blocks (block 5) and submenus to clear buffers and exit the editor (block 6), insert characters (block 7), and manipulate lines (block 8). The remaining task is to tie them together.

which expects an address and count on the stack, is to reduce the count by the number of spaces from the end of the line. –TRAILING calculates the number of spaces necessary to eliminate extraneous characters that might otherwise be shown beyond the 64-character line.

By the end of the fourth block all low-level words have been defined, in particular, all words related to memory addresses, positioning the cursor, and displaying text on the screen. These words are tested and debugged, which speeds up the testing and increases the reliability of the words to come. The remainder of the editing commands are defined in the next four blocks.

EDITING FUNCTIONS

Once the foundation has been laid, the major portion of the editing commands is written. These commands rely more heavily on words defined in this particular program than on predefined FORTH words. The intermediate and highest levels of a FORTH program are usually the most interesting to write because they are defined using words customized for the application.

The order in which intermediate-level words (see figure 7) are defined is somewhat arbitrary because most of them stand on their own. It is generally a good idea, however, to group related words in the same block, if only to make them easier to find and edit.

BCLEAR and SCLEAR clear the contents of the ring buffer and the video display, respectively. LOADBLK (load block) loads the block buffer and then moves its contents to the edit buffer.

RESTORE loads the edit buffer and displays its contents, erasing changes made since the last UPDATE. Although not in the original program specification, RESTORE proves to be an excellent "undo" command for the user. RESTORE is just one example of a major benefit of incremental design and testing: a low-level word written for some ad hoc purpose proves to be surprisingly general and powerful.

The <UPDATE> function copies the displayed portion of the edit buffer into a block buffer and marks the block buffer to be saved. Its name is in angle brackets to suggest that it is closely related to both the FORTH word UPDATE and the editor program word UPDATES (which is defined in the next block).

To start editing the next or previous block, +BLK or –BLK is used. The block being exited must be updated first to save changes. HIGHBLK and LOWBLK, which were not in the original specifications, were added to keep the editor from attempting to access forbidden or nonexistent blocks. For that matter, +BLK and –BLK were not specified originally either. Because a good toolkit was already in place, adding these functions was a minor matter. In other languages such an addition might have entailed considerable reprogramming and additional code. Again, the simultaneous top-down and bottom-up approach permitted improvements to be made quickly.

CLRTOP (clear top) and WRITETOP (write top) were included to simplify writing the prompts used for the four words in block 6. Together they save the cursor position on the stack and blank the top line on the terminal, then they restore the top line and put the cursor back where it was.

The words in block 6 provide the user with or prompt for information. The first word, ?BLK# (block number?), displays the current block number on the top line, pauses, and then restores the original top line to the display. It simply reminds the operator of the

block being edited; the length of the pause is determined by the constant PDELAY. UPDATES performs an update of a block, then reports its action. The display is necessary only to indicate that the update has taken place. (Note that factoring out subsections of the definition has resulted in very readable code and a notably brief definition of a complicated function. The words defined here could be viewed as a new language, dedicated to creating an editor.)

ASCII, available in some dialects, is defined purely to enhance the readability of the code for the next two functions. BL WORD parses the word following ASCII (up to a delimiting space) and leaves the address on the stack where the string has been copied, in counted form (a count byte followed by the string itself). The first character of the string is one more than this address and it is fetched to the stack. Then, if FORTH is in compile STATE, the character on the stack is compiled along with LITERAL; otherwise, the ASCII value of the character is left on the stack. (LITERAL must be compiled using [COMPILE] because it is an intermediate word.) Although this definition is quite involved, it demonstrates the ease with which functions are defined using words such as WORD and LITERAL.

The last two words, ?CLEAR and ?EXIT, provide submenus to permit related functions to be assigned to a single Ctrl-key combination in the main program. In ?CLEAR, if *B* is pressed, the buffer is cleared and the top line and cursor are restored; if *S* is pressed, the screen is cleared and the cursor is restored; if some other key is pressed, the top line and cursor are restored but nothing else is done. ?EXIT sets a flag to exit the editor, and it works in a manner similar to ?CLEAR. The word 1+ changes the false flag floating on the stack to true, causing an exit from the editor in EDITLOOP (defined in the last block). If *S* is pressed, extra characters are dropped from the stack, the block buffer is saved to disk, and the flag is changed to signal an exit; if *Q* is pressed, the block buffer is cleared so it will not be saved; if some other key is pressed, the top line and cursor are restored but nothing else is done.

Block 7 contains the words needed to enter and alter text. Two basic modes are used to enter a character—replacing the character at the cursor or opening the text (by moving the rest of the line one space to the right) before inserting a new character. ENDCLEAR? checks for a blank at the end of the cursor line, which determines whether or not a line should be opened, and thus prevents inadvertent loss of characters.

OPENUP inserts a space at the cursor position before a character is inserted. It acts only on the buffer (with no display of anything), so it can be used both in OPEN and INSERT. OPEN inserts a space at the cursor, moving the text one character to the right. It is a variation on OPENUP. TRUNC (truncate) blanks the characters from the cursor to the end of the line, both on the display and in the edit buffer.

The next word, OVERTYPE, is the basic word to replace a character at the cursor position with the character on the stack. If the cursor is not beyond the end of the line, the character on the stack is displayed on the terminal and stored at the cursor position in the edit buffer. The cursor position in the buffer (COL) is incremented to keep it in step with the terminal cursor, which moves one space to the right when the character is displayed.

INSERT calls OPEN, replaces the blank produced at the cursor position with the character on the stack, and

displays the line. Deleting a character using DELETE is accomplished by moving the text between the cursor and the end of the line (in the edit buffer) one space to the left, storing a blank at the end of the line (in the buffer), erasing the line on the terminal, and displaying the changed line. HACK deletes a character to the left. When the cursor is in the first column, the behavior of HACK is the same as DELETE .

The next block, number 8, works with the undisplayed buffers (the line and ring buffers). The line buffer, which receives a copy of a line that will replace a line somewhere else, is particularly useful for storing an index line that is used in several blocks. All deleted lines are saved in the ring buffer. Those lines then may be inserted in another place in the same or another block. To delete a set of lines completely, TRUNC them with the cursor on the left margin before deleting them into the ring buffer. BCLEAR then will clear all lines in the ring buffer (defined in block 5). The text displayed on the display screen, after all updating is complete, is saved to disk.

CLINE (copy line) and PLINE (put line) work together with the line buffer (at LBUFF) to copy and replace a single line. (A useful modification would be to continuously display the contents of the line buffer below the block being edited.) KLINE (kill line) deletes the line in which the cursor sits from the displayed part of the edit buffer and moves it to the ring buffer at BLINE . Then the entire edit buffer, from the line after the cursor to BLINE (the end of the ring buffer), is moved up by a line (64 characters) so as to close up the line that was deleted. SHOWLINES then displays the lines from the cursor line to the bottom of the screen. The last line now displayed on the screen had been the top line of the ring buffer, which was, in effect, rotated up a line.

Like KLINE , ILINE (insert line) merely moves lines between the screen and ring buffer. The entire edit buffer from the start of the cursor line to one line above BLINE is moved down 64 characters and the last line (now at BLINE) is moved to replace the former cursor line; the changes then are displayed by SHOWLINES . This movement, in effect, rotates the ring buffer down a line. BLINE (the 17th line in the ring buffer) is needed to give room for rotating the ring buffer.

With the functions all defined, the remaining task is to tie them together so that the editor performs as originally specified. This will include adding the functions that were created during the programming process.

THE HIGHEST LEVEL

The commands (functions) are invoked using Ctrl-key combinations (typing them directly from the keyboard would enter the command names into the edit buffer). While the editor is running, the keyboard is continually scanned by KEY , which returns the ASCII code of the key pressed to the stack. If the code belongs to a Ctrl-key character, the appropriate command is executed. The easiest way to access all 23 editor functions is to create an *execution vector* for the command words (as many as 26 for combinations using keys *A* through *Z*). The word ---- was created (in block 1, figure 4) to sound a beep if an undefined Ctrl-key sequence is used.

The word] puts FORTH in compile mode so the code field addresses (CFAs) of the editor words are compiled in a single 26-element array, the starting address of which is left by KEYVECTORS (see figure 8). The word [puts FORTH back into execute mode.

FIGURE 8: *Ctrl-key Definitions*

```
( Program Editor                              Block 09 of 10     )
CREATE KEYVECTORS   ]            ( edit commands execution vector )
  LEFT     ( A Left cursor        ) ?BLK#    ( B Block number     )
  CLINE    ( C Copy line          ) DELETE   ( D Delete char      )
  ?EXIT    ( E Exit editor        ) ----     ( F                  )
  MODE     ( G Get new mode       ) HACK     ( H Delete back      )
  ILINE    ( I Insert line        ) ----     ( J                  )
  KLINE    ( K Kill line          ) -BLK     ( L Last block       )
  NEWLINE  ( M or ENTER, CR+LF    ) +BLK     ( N Next block       )
  OPEN     ( O Open text          ) PLINE    ( P Put line         )
  <HOM>    ( Q Home cursor        ) RESTORE  ( R Restore screen   )
  RIGHT    ( S Right cursor       ) TRUNC    ( T Truncate line    )
  UPDATES  ( U Update to buffer   ) ----     ( V                  )
  UP       ( W Up cursor          ) ?CLEAR   ( X Clear buff/scr   )
  ----     ( Y                    ) DOWN     ( Z Down cursor    ) [
: KEYDO ( n -- ) 1 MAX 26 MIN 1- 2 * KEYVECTORS + @ EXECUTE ;
```

Although FORTH is susceptible to unreadable code, the unorthodox word KEYDO increases readability. By indexing programs stored in an array, KEYDO serves the function of Pascal's CASE statement or BASIC's ON GOSUB.

FIGURE 9: *High-level Words*

```
( Program Editor                              Block 10 of 10     )
: EDITCASE ( flag char -- flag' )
  DUP 27 < OVER 0 > AND
  IF  KEYDO
  ELSE DUP 31 > OVER 127 < AND
     IF I/R @
        IF INSERT ELSE OVERTYPE THEN
     ELSE DROP ----
     THEN
  THEN ;

: EDINIT ( blk -- ) SCR ! EMPTY-BUFFERS LOADBLK SHOWBLK ;
: EDITLOOP ( -- ) EDINIT 0 BEGIN KEY EDITCASE DUP UNTIL DROP ;

: EDIT ( blk -- ) <HOM> <CLR> EDITLOOP <HOM> <CLR> ;
: E SCR @ EDIT ;
```

The EDITCASE word is the FORTH translation of the program specification set forth in figure 4, and closely follows that outline. In order to invoke the editor, the user can type E to edit the last block listed or n EDIT to edit block *n*.

KEYVECTORS is the FORTH execution vector. When a word's CFA is passed to EXECUTE, the word is executed. To execute any one of the edit words, it is necessary only to index into the execution vector, fetch the CFA, and pass it to EXECUTE. This is done by KEYDO.

KEYDO takes a number, limits it to the range 1 to 26 inclusive, (Ctrl-A to Ctrl-Z) and executes the *n*th command in KEYVECTORS. Now any one of the editing commands can be executed given a single Ctrl-key sequence from the keyboard. KEYDO demonstrates the easiest of several methods of implementing a case construct in FORTH.

In block 10 (see figure 9), everything comes together. EDITCASE, the editor's critical word, is where keyboard input is analyzed and acted upon. EDITCASE expects a flag and a character on the stack. The character is first checked to determine if it is between Ctrl-A and Ctrl-Z inclusive. If it is, the appropriate command is executed; if it is not, the character is checked again to determine whether it is a displayable ASCII character. If it is, and depending on the insert/replace status, the character is either inserted or typed over in the edit buffer or it is discarded if unprintable and a beep is sounded. The flag in EDITCASE controls exiting the

editor. The flag (0, or false) is put on the stack by EDITLOOP (defined below) and changed to 1 (true) if the exit option was chosen in ?EXIT (in block 6).

Thus EDITCASE is the FORTH translation of a key portion of the specifications set forth earlier. Note the parallel between the definition of EDITCASE and the specification for the program in figure 2. That outline is now an executable program; it has been supported by a specialized "editor language" developed in FORTH. Although EDITCASE contains the main logic of the editor, a few more words still are needed to make it completely functional. The block to be edited must be loaded into the edit buffer and an indefinite loop must be used to repeatedly sample the keyboard input with which EDITCASE needs to work.

EDINIT (edit initialize) stores a block number in SCR and performs an EMPTY-BUFFERS to clear the block buffers, then loads the contents of the block into the edit buffer and displays it on the terminal screen. EDITLOOP initializes the editor using EDINIT, places a 0 flag on the stack, and starts an indefinite loop that samples each key pressed. The keys pressed are handled by EDITCASE. DUP provides an extra copy of the flag for testing by UNTIL (each time the flag is tested, it is taken from the stack); looping continues until the flag is changed by ?EXIT, after which the extra copy is discarded.

This completes the program editor development. The editor is invoked with EDIT or E. **n EDIT** homes the cursor, clears the screen, and enters EDITLOOP with a block number on the stack. When editing is complete, the screen is cleared again. E gets back to the most recently edited block, the number of which is stored in SCR.

The editor was initially created with a minimum number of functions in order to have a framework within which to test new commands as they were developed. Thus, EDITCASE, EDITLOOP, KEYVECTORS (mostly filled with the word ----), and KEYDO were written before many earlier words were defined. As the editor grew, related words were grouped into blocks and newly created low-level words were put in the first few blocks. Once the editor was running, new commands were added and debugged.

The program code was developed in the following sequence: a core of low-level words upon which everything else depends, high-level words for testing, intermediate-level words for most of the editing commands (more low-level words were added as needed), and debugging/fine-tuning. Writing an editor with the same capabilities using dialect-dependent words would take far less time; the goal here was as generic an editor as possible.

To test the editor, a terminal driver was written that allows a FORTH computer to talk to a dumb terminal. Working with a UART (universal asynchronous receiver-transmitter) manual, the driver was up and running in less than three hours. This was possible because FORTH offers direct access to memory and ports, thus the serial communications functions were easy to implement without using assembly language. The editor with the terminal was tested by loading the three terminal driver blocks (which implemented every UART function) before the editor blocks, and then redirecting FORTH I/O (KEY and EMIT) to the RS-232 port.

AN ATTRACTIVE LANGUAGE

New users often are struck by the synergism of FORTH. Its user-friendly nature is an unexpected by-product of its unique architecture. Words such as WORD, –TRAILING, [COMPILE], and IMMEDIATE are unknown in other languages—these and the other functions available in the FORTH lexicon comprise a generous set of operators for writing programs and modifying the function of the language itself. For example, nothing prevents FORTH from compiling executable machine code rather than the list of addresses that constitute compiled FORTH code, and some dialects provide this facility. More importantly, even if none of the dialects available provide the functions or environmental features necessary to a particular task, FORTH provides the tools for operating in a customized programming environment. This often involves far less work as well. The FORTH programming environment is an especially rich one, both for planning and implementation of applications.

The FORTH program editor, presented as a series of source code blocks in figures 4 through 9, can be constructed by putting the blocks together. The complete listing also is available from PCTECHline (as EDITBLCK).

Mahlon G. Kelly is an associate professor of environmental sciences at the University of Virginia. Nicholas Spies is an award winning film editor at Carnegie Mellon University. They are coauthors of FORTH: A Text and Reference *(Prentice-Hall, 1986); portions of this article are derived from their book.*

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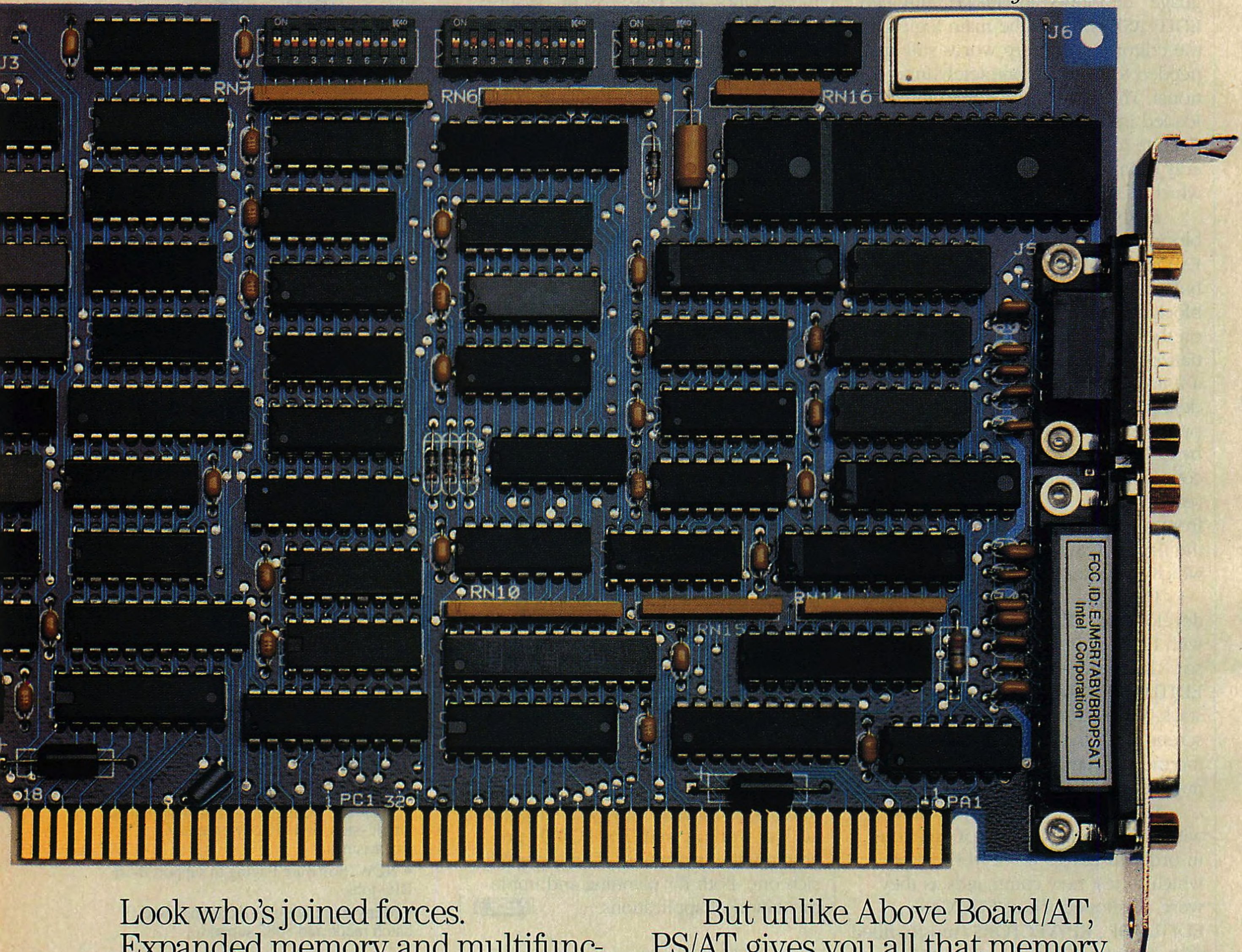

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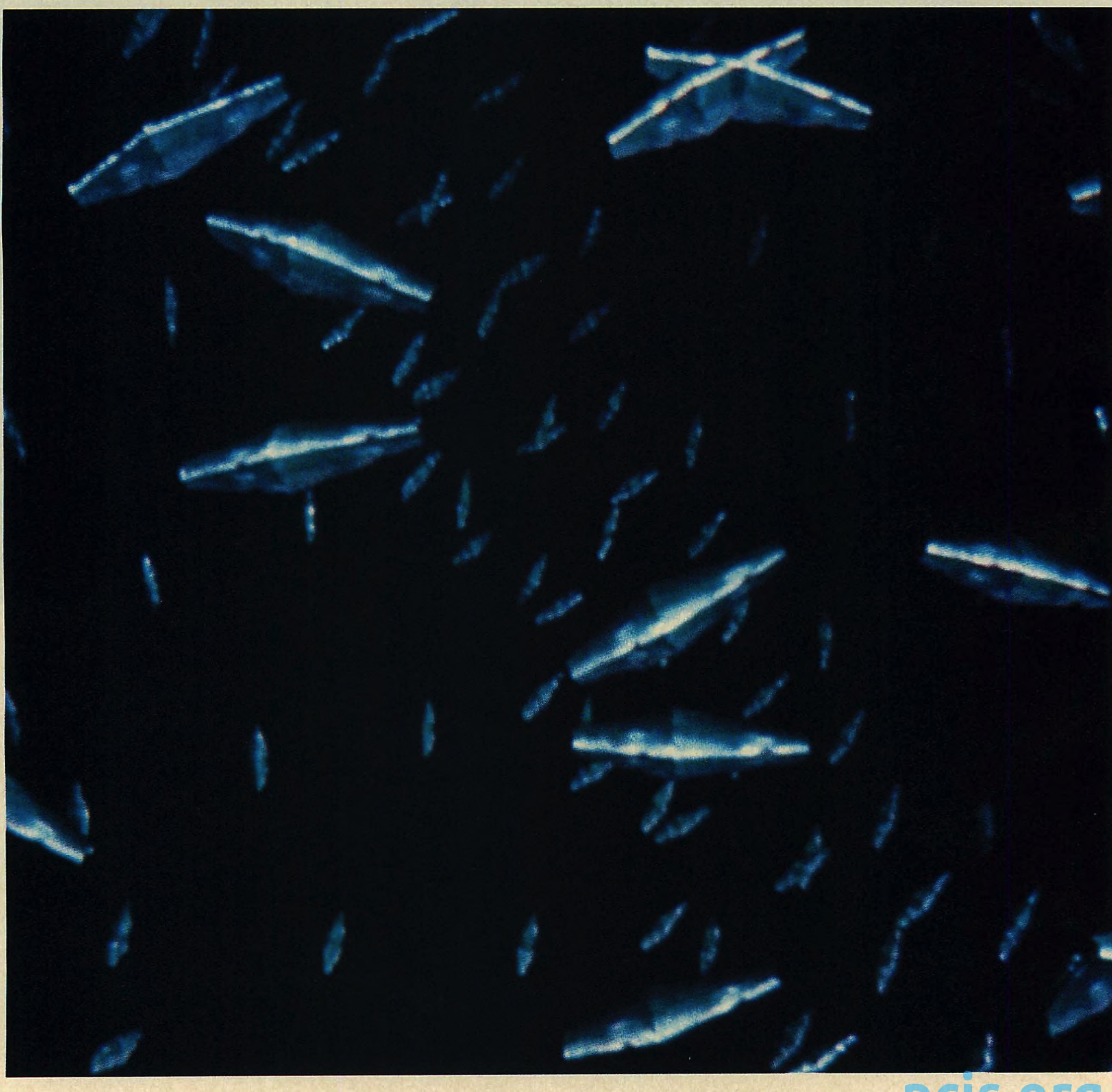

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TAS-Plus offers an inexpensive alternative in data management for the experienced application developer.

JIM ROBERTS

At the core of every modern-day accounting system is a flexible data manager. Business Tools, Inc., which offers two modifiable accounting systems, is now marketing the engine of those programs as a stand-alone product. Called TAS-Plus, this inexpensive data manager is based on the relational data model and is fully programmable.

Developed by Philip Mickelson, the original author of The Sensible Solution from O'Hanlon Computer Systems, TAS-Plus derives from a more primitive data manager, TAS (The Accounting Solution), released last year. The company is promoting TAS-Plus as an alternative to dBASE III PLUS. The program can import and export dBASE III DBF files. (dBASE III PLUS was reviewed in "A Data Manager: The Evolving Standard," Dave Browning, May 1986, p. 166.)

A PC with DOS 2.0 or later and at least 512KB (preferably 640KB) of RAM is required to run TAS-Plus. The program has a number of features specific to the PC and DOS, so that it does not run under the wide variety of operating systems that the earlier TAS does. It supports both monochrome and color monitors. A hard disk is a necessity.

TAS-Plus is not copy protected, nor is any tedious unlock procedure necessary. TAS-Plus is shipped on two diskettes. One contains a demonstration version with a 250-record maximum; the other is a fully enabled version. TAS-Plus is available for both single- and multiuser systems. The multiuser version runs on PC networks that use the DOS 3.1 network system calls.

The core of the TAS system is written in assembly language; many of the utilities, including the menu-driven editor, are written in the internal procedural language. The developer's version (2.04) includes 275KB of system source code. (A limited version without source code is available, but it is not recommended.) The code not only gives the developer access to the internals of the data manager, but also provides an enormous quantity of functioning code from which to work in learning the TAS-Plus language. TAS-Plus compiles to an intermediate token code that is then executed by an interpreter.

Source code is supplied for all the TAS-Plus utilities, which include: an editor for writing the coded form of the source code; a utility for displaying, changing, adding, and deleting records; a browse utility for modifying the data in existing records; two data dictionary management programs; a screen generator; a report generator; an installation program; and several data and source code conversion programs.

Basic installation of TAS-Plus is not difficult, but it is not clearly documented. The program can be copied from the distribution diskettes into any directory on a hard disk. A simple installation program, TASINSTL, in the TAS-Plus language can be run from the main menu. It sets the normal, highlight, and reverse colors, cursor size, the decimal character, the date type, the name and path for the temporary file used during database restructuring, the box type used around menus and windows, and the printer control strings. A few colors are demonstrated by running the TAS-Plus program COLOR, but to install the colors the user must enter the decimal codes in TASINSTL, exit to DOS, and restart. The settings are stored in the file TAS.OVL.

With version 2.04 (reviewed here) or later, the cursor is invisible with the IBM Color Graphics Adapter or Enhanced Graphics Adapter. Instructions to fix the cursor problem are buried on page 342 of the manual under "Exiting and Updating TAS-Plus;" a sheet may be included with the documentation warning the user of this deficiency. Because this program is written for the PC, there is no excuse for its not reading the equipment list using INT 11H and adapting automatically.

A programmer can set up standard sets of printer control characters to be sent on command. TAS-Plus has no other identification of the sequences besides the numbers 1 through 20; they can be sent only by calling them by number with a function call. This idiosyncrasy obscures what should be a transparent feature of the program. For example, all programmers who are working with a copy of the development system must remember what **pchr(P,7)** does and on which printer.

The printer codes also are installed in the TAS.OVL file. When installing an upgrade or patch, care must be taken not to overwrite the .OVL files. The manual does not give any warning about these serious consequences; it neither indicates where the information on printer control codes is stored, nor how that information can be preserved.

An accounting system or data manager should be able to support both a dot matrix printer for internal accounting reports and a letter quality printer, using different control codes or escape sequences. With TAS-Plus this can be done in a tricky way by defining different .OVL files, but the procedure is not documented. VARs (value-added resellers) are advised not to use this procedure, if they looking for peace from their customers.

DATABASE DESIGN

TAS-Plus is a partial implementation of the relational data model, but without the structured query language (SQL). It has a relational algebra, but no relational calculus. (See "A Perspective on Data Models," C.W. Holsapple, July 1984, p. 113.) The data are stored in independent tables with no defined relations between the tables. A table, stored in a master file, is indexed by B+ trees, which are kept in a single key file—one per master file.

All file structures and fields are defined in a data dictionary file. A locator file tells TAS-Plus to which structure each data file belongs and in which logical drive and directory each file (master and key) resides. A master file and its key must be kept in the same directory. The earlier TAS program allowed them to be kept on different drives, which often improved performance.

Fields and records are of fixed length within a table. Arrays of fields have a fixed number of elements. Storage of variable-length text takes more disk space than would be used by data managers that allow variable-length fields. TAS-Plus records, as stored on disk, expand in single-byte increments as fields are added or expanded. Thus, TAS-Plus data files do not waste any more disk space than is required by the fixed field lengths.

The database specifications do not have any numerical limitations that are significant for normal applications. Records may contain a maximum of 10,254 fields, up to a total of 10,254 characters. TAS-Plus files may contain as many as 16,776,960 records.

The program offers a satisfactory variety of data types: alphanumeric (character), numeric, time, and two date formats—short (MM-DD-YY) and long (MM-DD-YYYY); any of these data types may be a key. Also supported are one-dimensional arrays of up to 255 elements of any of the five data types. Array fields may not be keys. Alphanumeric fields may be 255 bytes long. The handling of numeric fields is optimized for business applications. Numeric fields may be up to 20 characters long and are stored in compressed BCD (binary-coded decimal) form, with no exponent part. Dates are stored as BCD sequential Julian days, and time is stored as BCD minutes from midnight, to be used in numeric computations. Date and time keys are ordered by numeric value.

Because TAS-Plus has no data type *real*, it cannot use the Intel numeric chips to speed up numerical computations on the data, nor can it be employed for scientific database applications that use numbers with a wide range of magnitudes.

In the use of numeric fields there are a few quirks that seem to pose some serious questions about the suitability of TAS-Plus for software development. Quoting from page 150 of the manual, where this crucial warning has been thoughtfully buried:

> If a numeric field will hold a negative value, it must be defined in the program or in the data dictionary as being an odd number of characters in length....For example, a field defined with a size of 9 can hold the negative value −100 whereas a field defined as 10 characters long cannot....Numeric fields that have decimal places must have the number of decimals defined as an even number (2, 4, 6, or 8).

No discussion of what runtime errors might result from violating these rules is given. In many applications, numeric fields may have negative intermediate values during the course of long calculations, even though the final result is positive. If the numeric field is of even length, it cannot even be tested for negativity.

Up to 32 key fields per file are kept in a single key file. As many as 16 master data files can be open at one time. Data that are imported or entered into a table are automatically indexed, according to the existing definition of the table when it was initialized.

DATA DICTIONARY

The data dictionary is the key to TAS-Plus's data management. When the database specifications are changed and any data files restructured or reindexed, TAS-Plus programs do not need to be recompiled. In fact, most compiled applications do not require the data dictionary in order to run.

Files, erroneously called *databases* in TAS-Plus, are defined in an indirect fashion, which the TAS-Plus manual does not clarify. Within the data dictionary, file structure is defined by *schemas*. (TAS-Plus's use of the term schema does not agree with conventional use in which schema refers to the overall database design, including entity types, attributes, and interrelationships. Business Tools's meaning of the term is closer to *file template* or *entity*.) A schema definition contains all field names, lengths, offsets, types, overlay, and key status information. It also defines the number of digits in the numeric fields, the case of the alphanumeric fields, and whether or not the field is an array.

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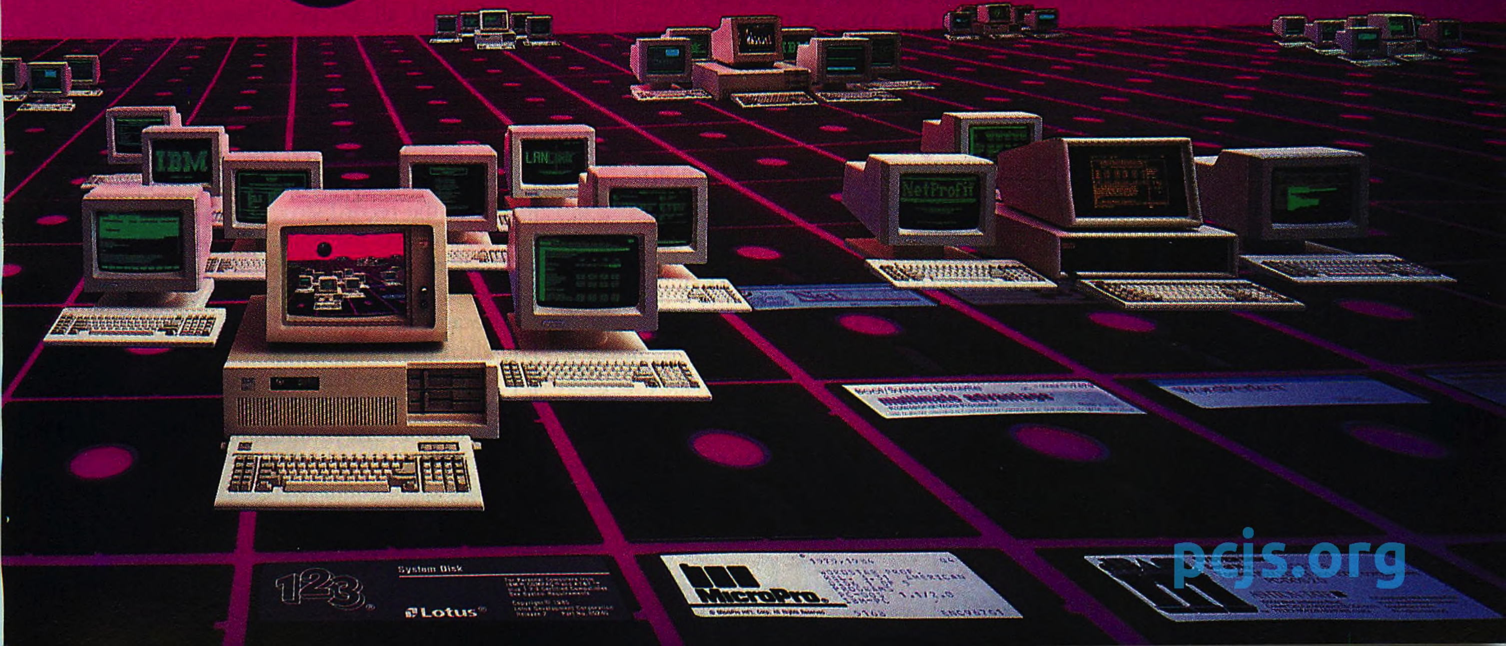

Files' names are found in the disk directory and in the locator file TASFILE, not in the data dictionary. TASFILE is used to locate a TAS-Plus data file and to get the name of its schema. TAS-Plus then looks in the data dictionary file for the schema name, which yields the structure of the data file and the names of its fields. Earlier versions of some TAS-Plus utilities incorrectly assumed that the schema and file name were always the same.

Files can be indexed only on single fields that are defined in the schema. Fields can be derived from other fields or they can be overlay fields. The optimal use of overlay fields as keys requires some advance planning on the structure of the file schemas. An overlay field may have any offset and length within a schema; it partially or completely overlays the basic fields. It does not have to be a key, but that is its usual purpose.

To index on a person's last name followed by the first, the last name must be placed before the first in the data dictionary schema definition. An overlay field has to be defined to cover the last name and some part of the first.

Several curious examples of reverse evolution are found in Business Tools's current data dictionary manager. The data dictionary manager can no longer insert fields into a record; they only can be added to the end. It also no longer displays the cumulative offsets for the fields entered so far; to enter an overlay field, offsets must be laboriously computed. No utility can get a print-out of the structure of the database—that is, of the schemas, files, and fields. In fact, no print routine is available in the data dictionary manager.

DATABASE MAINTENANCE

TAS-Plus is similar to The Sensible Solution and to Data Access Corporation's DataFlex in that it has no interactive command line mode, such as that of dBASE. Database maintenance in the interactive mode is limited to entering and deleting records in displayed files, finding records, editing fields, and controlling application program flow. These operations are performed with program function keys, very similar to the execution control keys of The Sensible Solution and the flex keys of DataFlex. (DataFlex was reviewed in "A Data Manager for Diverse Environments," Chris Christian, August 1985, p. 52.)

TAS-Plus provides an internal utility to restructure a data file. After record layout modifications, such as changing a field length or adding and deleting fields, are made in the data dictionary, TAS-Plus upon request rewrites the existing data in accordance with the new layout. Any change to the record layout requires restructuring of the data file, although the key status of fields may be changed and overlay fields added or deleted without restructuring.

When keys or overlay fields are changed, all the files defined by the schema must be initialized and reindexed; otherwise data are added to the files with the structure of the old schema. Although initialization does not seem to be required after restructuring, it may be advisable. Initialization updates the record structure in the key file and sets the active record count back to zero. Therefore, the actual number of active records should be noted because it must be manually entered when the file is reindexed.

TAS-Plus database management operates in a logical and accessible fashion so that programmers who are very familiar with the internals can write quite sophisticated maintenance programs of their own in the TAS-Plus

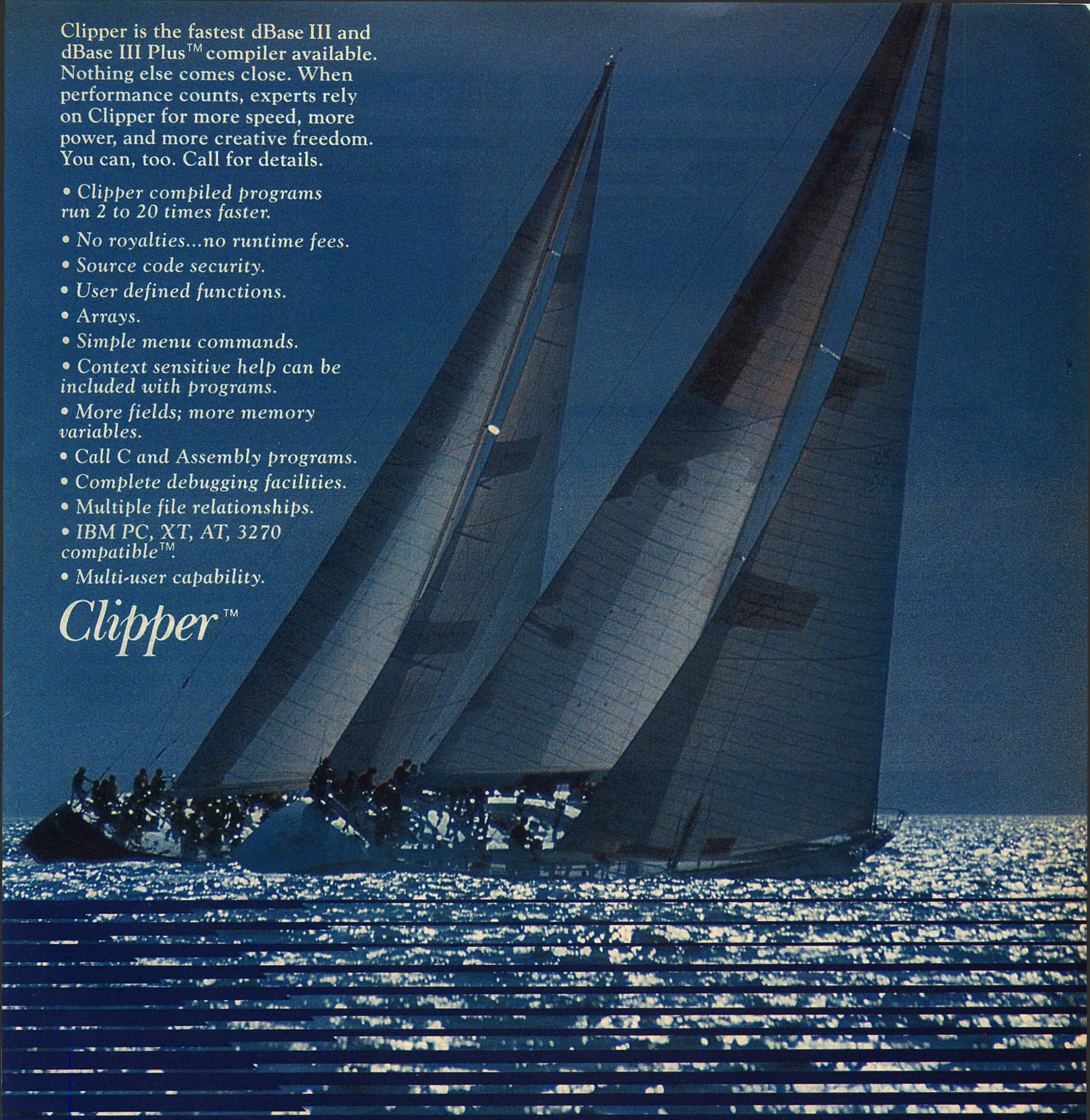

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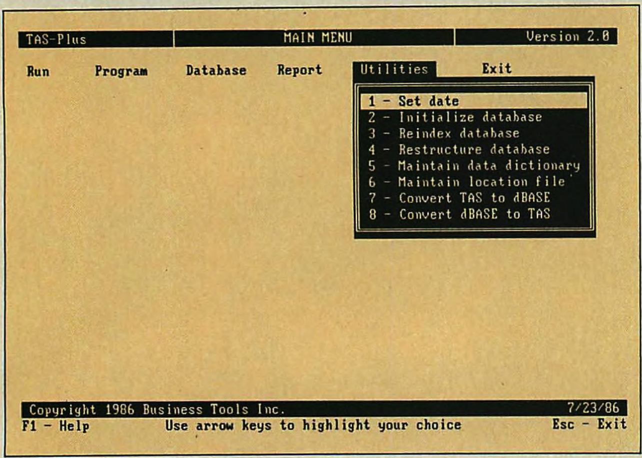
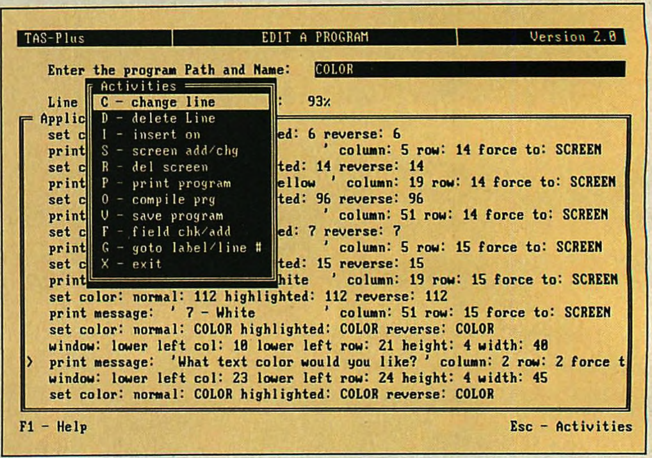
PHOTO 1: *TAS-Plus Main Menu*



Both TAS-Plus and its internal editor are operated through a hierarchy of logically arranged pull-down menus.

PHOTO 2: *TAS-Plus Editor Screen*



The editor translates coded language into easily understood commands that can be edited by menu selections.

language. It is not wise, however, for the developer to make more than trivial changes in the shipped utilities that form an integral part of TAS-Plus, because whenever Business Tools issues new releases, these programs frequently are changed.

FINE-TUNING NEEDED

A hierarchy of pull-down menus is the operator's primary interface to TAS-Plus and its internal editor. Photo 1 shows the main menu with the Utilities pull-down menu active. For the most part, these menus are logically arranged; they are not obtrusive and are reasonably self-explanatory. A modest amount of on-line help for the menus is available; more can be programmed.

These menus need some refining, however. They do not support mice, and they do not always behave in a rational way. For example, when a function completes, control is usually returned to square one—"Run a TAS Program." This is an inconvenience for a developer who generally prefers to stay in the same pull-down menu in order to perform a number of related operations together. The pop-up menus that are used in the screen and report generator and in other utilities exhibit the same irritating behavior.

A pull-down menu cannot be selected by pressing the first letter of the choice; instead, the user must position the cursor over the selection, using the cursor movement keys. Within the menu, however, the selection can be made either by pressing the appropriate number or by stepping to it with the cursor movement keys. This behavior is unnecessarily inconsistent.

One of the most impressive operating characteristics of TAS-Plus is the speed of the two-pass compiler. Using a small data dictionary on an 8-MHz AT with a 28-ms, 72MB CDC Wren disk, algebraic source programs compile at an impressive 2.6Kbps.

Both the compiler error detection and runtime error handling, however, leave much to be desired. Many syntax errors escape the compiler, just as the syntax itself escapes clear definition in the manual. These errors produce runtime errors of varying severity. Often, no message appears at all—just a hung computer or some obsessive disk activity with no result, requiring Ctrl-Alt-Del to interrupt. When a runtime error message appears, it is usually of little use.

Fortunately, a trace facility in the developer's version allows the user to step through the program and display field values. The facility does not dis-

FIGURE 1: *Algebraic*

```
open(scz)
nrec = (0)
gosub get.date
find(b,scz.code,norecs)
trap(p,g,tof)
mount(report,r,a)
start:
nrec = (nrec+1)
pfmt(6)
find(n,scz,finis)
goto start
```

The alegraic form of the TAS-Plus procedural language can be written by any standard text editor.

FIGURE 2: *Coded*

```
003,SCZ     ,,,,
022,GET.DATE,
039,P,G,TOF,
045,REPORT,R,A,,
039,O,G,NO.RECS,
005,REC.NUM,(1),
008,REC.NUM,SCZ     ,S,
039,O,G,FINI,
000,PRT.REC,
032,6,,,,,
005,TOT.RECS,(TOT.RECS + 1),
000,RD.NEXT,
005,REC.NUM,(REC.NUM + 1),
008,REC.NUM,SCZ     ,S,
021,PRT.REC,
```

Programs written with the TAS-Plus internal editor are stored in the coded form of the TAS-Plus editor.

FIGURE 3: *Interpreted Coded*

```
  open tas file:  SCZ
  gosub:  GET.DATE
  trap: PAGE BREAK GOSUB TOF
  mount:  REPORT type: R print on: A
  trap: FILE ERROR GOTO NO.RECS
  REC.NUM equals:  (1)
  REC.NUM equals record num:  SCZ set
  trap: FILE ERROR GOTO FINI
PRT.REC
  print report line:  6
  TOT.RECS equals:  (TOT.RECS + 1)
RD.NEXT
  REC.NUM equals:  (REC.NUM + 1)
  REC.NUM equals record num:  SCZ set
  goto:  PRT.REC
```

The TAS-Plus internal editor provides interpreted listings of programs stored in the coded form of the language.

play the source or the name of the command being executed, only the runtime line number. These numbers can be listed for coded source files using the TAS-Plus editor. A similar facility does not exist for the algebraic source; users must guess the location of errors.

According to Business Tools, dBASE III (but not dBASE II) files can be converted to and from TAS-Plus data files without writing any programs. As the dBASE data files are imported, the TAS-Plus data dictionary is updated to reflect the new fields. Some limitations exist because the methods of defining indexes differ, as do some TAS-Plus and dBASE data types. Indexes must be added to the imported entity; the TAS-Plus time data type is converted to dBASE character type; the dBASE logical type is converted to TAS-Plus alphanumeric type; and dBASE memo fields are converted to alphanumeric type, but the data in them are lost. dBASE III file conversion was not tested.

SPEAKING THE LANGUAGE

The TAS-Plus procedural language has two forms, a familiar algebraic form that can be written by any text editor and a coded form that is written with TAS-Plus's internal menu-driven editor. The two forms have the same syntax and almost identical functionality. The earlier TAS used a subset of TAS-Plus algebraic source code. Most of the utility source provided with the developer's version is in algebraic form.

Figures 1 and 2 show program segments that produce the same report, but are expressed in the two different forms of the TAS-Plus language; figure 1 shows the algebraic form of the language and figure 2 the coded form. Figure 3 is the interpretation of the coded form produced by the TAS-Plus editor.

The algebraic form can be written with any text editor. Each program should be ended with a blank comment line to assure that the TAS-Plus compiler will parse the entire program.

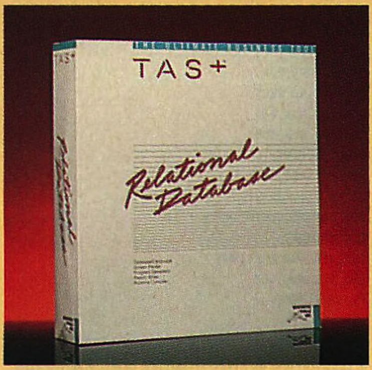
The TAS-Plus procedural language provides fairly low-level data access commands, such as **find record** and **find related record**. Because TAS-Plus operations are not defined on entire relations, operations using relational calculus must be specifically coded for each different use. Besides the inconvenience for the developer, the need to code such operations results in less than optimal runtime performance for some operations (such as joins), because TAS-Plus programs are not in native code. Even with this hindrance, TAS-Plus runs reasonably fast.

The syntax of the TAS-Plus procedural language is very simple and contains some structural features, including IF...THEN...ELSE, FOR, WHILE, nested structures, and recursion. The language is compact, and its simpler construc-

TAS-PLUS OVERVIEW

TAS-Plus, version 2.04
Business Tools, Inc., 4038-B 128th Avenue SE, Suite 266, Bellevue, WA 98006; 800/648-6258; in Washington, 206/644-2015

Product description. TAS-Plus is a programmable data manager based on the relational model. The developer's version 2.04 includes 275KB of system source code. A demonstration version of TAS-Plus is shipped with the full system and its source code.
IBM PC environment. TAS-Plus runs on any PC, PC/XT, PC/AT, or 100-percent compatible running DOS 2.0 or later with 512KB of RAM and a monochrome or color monitor. The accounting system requires a hard disk.
Other environments. No other environments are supported.
Network support. MS-Net support is provided through MS-DOS 3.1.
Copy protection. The product is not copy protected.
Documentation. A 356-page manual and 3 pages of errata are provided with TAS-Plus. The developer's version includes a 60-page supplement. The documentation is poorly indexed. Coverage of the TAS-Plus algebraic language is superficial. Command definitions and technical discussions are perfunctory. Several serious quirks in the program are completely undocumented, and others are glossed over.
User interface. Operation of the data manager and the accounting system progresses through a hierarchy of pull-down menus. An interactive command mode is not provided.
Help facilities. A very modest amount of on-line help is available from the



data manager; more help has been programmed into the accounting system for accounting functions.
Data dictionary. The data dictionary contains file templates called schemas. Files are identified to TAS-Plus in a locator file that specifies the relevant schema structure and the logical disk for the data file and its index file. Temporary variables can be defined as TAS-Plus fields in any procedure without entry into data dictionary. Text fields may be specified as uppercase only. Field names are unique to a schema (entity). As many as 1,369 (37*37) companies may be specified, each with its own independent set of data files described by the same file schemas. A TAS-Plus procedure can access any of these files.
Access to data files. Up to 16 files may be accessed by the same procedure, with the restriction that no more than 255 field names appear in the procedure. Records are accessed through a record buffer consisting of one record, whose structure is specified by a unique schema. To access or display more than one record at a time from a table requires the definition and use of temporary fields.
File capacities. TAS-Plus allows a maximum of 10,254 characters per record; 10,254 fields per record; 16,776,960 records per file; and 16 open data files, not including key files. Files are fixed-record length. Binary-coded decimal (BCD) representation of numeric and date fields reduces record size. B+ tree indexing is used, but hash or pointer indexes are not. One index file is permitted per data file, and up to 16 indexes are permitted per file (32 in the developer's version). Records can be indexed only on fields actually present in a data file, because indexing is part of data file definition. Overlay fields can be used to provide indexes using more than one field.
Field types/capacities. TAS-Plus supports character fields of 255 characters in length, numeric fields of 20 characters, two types of date fields (MM-DD-YY and MM-DD-YYYY), and a time field. Any data type may be a key. The program supports one-dimensional arrays of any of the five data types with as many as 255 elements. Array fields cannot be used as keys.
Data entry. A built-in facility permits data to be searched, entered directly into records, edited, or deleted. Data entry screens can be programmed or written with a screen painter; the layout of the screen is written into the data entry procedure itself. Forced data entry must be programmed. Data can be modified in any way desired before being saved to a file. Formatting characters in display fields is not supported. All indexes are updated automatically as data are entered, edited,

tions are fairly easy to understand and use. Compound logical expressions are not permitted, which can lead to some awkward IF...ELSE expressions. The language has a computed GOTO statement, called **on()**.

The implementation of structured programming is far from complete. For example, functions that find a record have a label branch-on-error. This label branching that is forced on the programmer produces a messy BASIC-like program structure. A better solution would be for the function itself to have a return value, as in C, or for a testable internal flag to be set, as in DataFlex.

TAS-Plus uses braces ({}) to define compound statements, or blocks, called *structures* in the often confused lexicon of Business Tools. Great difficulty was encountered during testing in getting nested IF...ELSE and WHILE statements to work with compound statements. Sometimes the tests would work for a few iterations and then mysteriously fail. IF blocks with a demonstrably false condition would be executed, and vice versa. A prior IF statement would affect the execution of a following one; a WHILE with a true condition would be skipped or executed only once.

After a great deal of experimentation, it was discovered that the malfunctions go away when labels are entirely eliminated inside compound statements. Although the manual does not say so, transfers of control entirely within a single compound statement seem to be forbidden; note that this is not the normally forbidden transfer to the interior of a block. GOSUBs involving transfers outside the block and then returning seem to be allowed. Because many TAS-Plus functions require a (GOTO label, not GOSUB) transfer of control when error conditions are encountered (record not found, for example), structured programming can become quite difficult. Until this problem is fixed, the natural mode of TAS-Plus programming will be spaghetti code.

Arithmetic expressions are parsed in a nonstandard way, which can easily cause errors that are difficult to find.

or deleted. If specified in the data dictionary, all data are made uppercase when entered.

Application development facilities. System development is supported through programming. TAS-Plus's internal procedural language comes in two syntactically equivalent forms: an algebraic form written with any standard text editor and a coded form written with an intrinsic dedicated editor. TAS-Plus has a relational algebra for manipulation of fields and records, but it does not include relational calculus for file manipulation. The source code for the data dictionary manager (written in the TAS-Plus language) is provided, allowing users to write their own database maintenance functions.

Security. TAS-Plus programs can check an entered password against a password stored in the program. Stored passwords are not encrypted.

Access to system facilities. External .BAT, .EXE, and .COM files can be executed from the TAS-Plus menu.

Query and sorting. TAS-Plus does not offer an on-line query facility or sorting. A report generator generates simple query programs. Any sorting of report output must be done using existing keys.

Reporting. All reports accessing more than one file or producing results other than simple totals must be programmed. The report format is specified in the report procedure. Data are printed by specifying which report line to print. As many as 60 distinct line types are allowed. Headers can be generated automatically, but footers cannot. Special character sequences for a particular printer can be installed; the maximum line length is 255 characters. Any operation permitted by the TAS-Plus language can be performed on the data before they are printed, including compilation of statistics and writing the data to foreign files for use in other programs. Reports can be directed to the screen, a printer, or a file.

Utilities. The built-in file data maintenance functions are initialization, rekeying, and restructuring. Indexes and overlay fields can be added or deleted using these operations. Data dictionary and location file maintenance utilities also are provided. Facilities are not provided for the recovery of any corrupted data.

Data compatibility. Data in TAS-Plus can be imported directly from dBASE III files. Importation of fixed field and delimited field ASCII data must be programmed specifically for each file structure. Only two ASCII date formats are converted automatically; other date format conversions must be programmed. Text data is not automatically made uppercase when stored in fields specified as uppercase in the data dictionary.

Distribution. Market distribution of version 2.04 of the product began in June 1986, through direct sales, OEMs, and resellers.

Price. Limited version, $69; developer's version, single-user, $199; developer's version, multiuser, $299.

Support. Registered owners receive free telephone support over a toll line. The updates are free or for a modest cost, in keeping with the TAS-Plus price structure.

—Jim Roberts

The manual states that the following expression has the value shown:

(10 − 1 * (2 * 4)) = 72

This is not an error. TAS-Plus has no hierarchy of arithmetic operators, unlike almost all other programming languages since FORTRAN and COBOL. It is not unreasonable to expect that a programming language should interpret arithmetic expressions more intelligently than a handheld calculator.

With the above caveats, after a few days of programming simple applications and learning the language syntax by a trial-and-error process, the programmer will find the simpler features of the TAS-Plus language natural. Only about 100 distinct commands exist. New programs are written easily as variants of those already tried and proven, which is what a developer wants.

The language permits menus to be programmed in a fairly compact form. However, the tutorial sections on this feature are so poorly prepared that they are an obstacle to understanding. The menu must be coded in an extremely precise form. If it is not exactly right, the program will compile, but the menu will behave in a bizarre way, and finding the bug will be difficult. To confuse matters, TAS-Plus has its own bugs in this area as well. Users would do well to follow closely the examples in the provided source code.

Some nonprocedural features of the language may be thought of as controlling the interactive behavior of TAS-Plus applications. The **trap()** function filters the interactive program control codes from the keyboard, takes note of whether a record is found or page break encountered, and offers graceful recovery from certain file errors. If one of these conditions is encountered, the **trap()** function tells TAS-Plus whether to ignore the condition, to take the TAS-Plus default action, or to transfer control to a specified location.

TAS-Plus supports 27 defined types of traps, each of which includes a default action. Unfortunately, the manual does not bother to tell the user what these actions are.

The only way to write relatively bomb-proof, graceful applications in TAS-Plus is to make liberal and canny use of these traps. Developers can prevent unchecked data from being saved to a file, interactive intrusion into a complicated database, and user interruptions of vital procedures that must go to completion—the worst aggravations for database application developers who have to support systems installed at the customers' sites. However, the incautious use of traps can result in program situations from which no graceful exit is possible. Customers tend to take whatever steps are necessary, which can lead to corrupted data.

TAS-Plus permits the definition of temporary variable fields through the **define()** function. A maximum of 255 named fields, both temporary memory fields and permanent data dictionary fields, may be defined or used within a single program.

The TAS-Plus language has reserved words, but the programmer must find out what they are by trial and error; no list is available in the documentation. Furthermore, no error messages are issued for them. Fields can be defined with reserved word names, but if the programmer has the temerity to use them, the compiler will pick out some perfectly innocuous language token such as = and say that it is not an acceptable field. The reserved words are not always obvious.

TAS-Plus automatically converts one data type into another if the types differ on opposite sides of an assignment statement. However, the ASCII-to-date conversion does not work properly. Business Tools is fully aware of this but has not provided any cautions to programmers in the manual or other pertinent materials. This problem is discussed more fully below.

THE TAS-PLUS EDITOR

The editor reads an ASCII file with the TAS-Plus language represented in a code and translates it into commands on screen that can be edited by menu selections and field entries. The statements as displayed by the editor are shown in the manual. They are completely unlike statements in the same language written in the conventional *algebraic form. Photo 2 shows a screen of the editor displaying a portion of the file COLOR.EDT, with the master pop-up menu active.

The editor is written entirely in the algebraic form of the TAS-Plus language. Its source code file is the largest supplied by Business Tools, at 125KB. Because the editor is written in the TAS-Plus language it must be run by the TAS-Plus interpreter. The response was painfully slow on an 8-MHz IBM PC compatible, and not much better on an actual 8-MHz AT.

Another burden imposed on the editor is that of interpreting the coded .EDT file into understandable statements for display. A standard PC does

not have the horsepower to sustain an editor with this dual burden.

The editor has other limitations. It has no block copy, move, or delete functions; no reading of block from a file or writing to a file; and no string search. Source code cannot be commented out; statements to be disabled temporarily must be deleted. The only way to save a source program is to leave the editor. The company plans to add some of these features.

The TAS-Plus editor also suffers from clumsy handling characteristics. When entering a program with any editor the user ofter wants to change the last line entered; this is especially true with this editor, because the line cannot be seen until after it has been saved. To change the line the user must first save it, switch from Add/Insert mode to Change mode, and then get into the line. This requires four keystrokes (Esc, Esc, I, <CR>) and passing through two menus when a single keystroke should be all that is necessary. TAS-Plus should be able to use Alt-key combinations, as most other editors do.

The coded source programs can be written directly with a text editor using very compact statements, but the syntax of the commands is not documented anywhere. If a coded source file (.EDT) is written or modified with many of the standard text editors, more often than not the TAS-Plus editor will send some lines off into a Kalusa-Klein dimension or run wild on the disk whenever it tries to load the file.

This behavior seems to be caused by the presence or absence of ^Zs at the end of a file. WordStar, which fills the buffer with ^Zs, seems to work with .EDT files and the data import programs. Other editors that do not use the ^Zs do not work with .EDT files. Data import programs often end abnormally when importing files edited with incompatible editors.

An available utility translates the TAS algebraic source into TAS-Plus coded source, but it is slow and the implementation is incomplete. Algebraic source with the TAS-Plus extensions cannot be translated, nor can coded source be translated to algebraic. A utility to perform translations of the full algebraic source to coded is planned, but the most needed translation facility, from coded to algebraic, is not.

GENERATORS

The user enters the TAS-Plus screen painter (generator) by selecting "Create a Program" from the Program menu. The selection brings up two irritating screens on the use of the generator and what it can do. The use of this generator is not recommended. It has frustrating conventions and a fragile constitution. Furthermore, it generates coded source, which is to be avoided. Screen programs can be written fairly easily and transparently in the algebraic source form with a good text editor.

A screen cannot be modified through the screen painter directly, however. The TAS-Plus editor allows the user to change existing screens and to add or delete screens through the menu system by calling on the screen painter within the editor.

The Del key in the screen painter puts the screen into apparent half-duplex mode: every character entered is duplicated. Pressing Del again returns the screen to normal behavior. Pressing Del and the left arrow destructively deletes characters by copying the space to the left. Until Del is pressed again, the backspace and cursor left keys copy to the left any character above the cursor, just as the other arrow keys copy in their respective directions. Although

this feature is not mentioned in the tutorial section, the mystery is solved by a couple of sentences buried on page 174 of the manual. The behavior is intentional on the part of the developer, who does not plan to change it. It is part of a feature that lets the user draw designs on the screen with any of the characters in the IBM character set.

Drawing boxes is convenient, but erasing them is not—especially the vertical sides. The manual says that boxes must be erased with the Space Bar, but they are most easily erased by using the Del key to copy spaces as described above. Business Tools plans to remedy this deficiency.

When numeric field specifications are entered into the data dictionary by way of the screen painter, a warning is displayed that the number of decimal places must be two, four, six, or eight. However, the screen painter allows odd numbers and even a number of decimal places larger than the total length of the numeric field to be entered without complaint. When this is done, a very long field is painted, and the computer has to be rebooted.

The report generator, by contrast, is a useful tool—a model for what the screen generator should be, although it is still more of an inquire function acting on a single table. The generator allows the user to produce a simple columnar report, selecting fields from a single file and listing the chosen fields for a single inclusive range of values.

The report program partially listed in figure 3 was written by the report generator in about 30 seconds. The corresponding algebraically coded program took an hour to code by hand and debug. The produced report is not well formatted. The data columns are not centered under the titles, and the columns are not centered on the page. A user may choose to total on any numeric field. However, it is not possible to total on time fields to add time intervals, even though the time is stored internally as a number.

The report generator produces a coded source file, which is automatically compiled. Features such as more sophisticated selection criteria, look-ups in another file, or averages can be added easily with the TAS-Plus editor.

The generated report does not contain traps allowing a graceful exit if a user decides to cancel the report at midpoint. A straightforward procedure could modify the report generator to include default traps.

The current version of the report generator has a serious deficiency in its ability to total numeric fields. The same length numeric field is used for the total field as for the original data field. If the total is larger than that field allows, no error message is issued nor is any indication given, but the most significant digits are lost.

The user can go into the source for the generated report program and add to the lengths for the total fields. This is not a trivial procedure, because the defined length must be changed in two places and the printing position in the report format moved. This flaw defeats the convenience of a report generator.

Fortunately, a better solution exists, which demonstrates the value of TAS-Plus's open, programmable system. During the testing for this article, specific changes were made in the source code for the report program generator TASCRRPT.EDT that caused it to define the total fields as two places longer than the data fields and consistently use these larger fields in generating the report program. The result may not be elegant, but it does work. Perhaps Business Tools will add this modification to its future releases.

PROGRAMMED FORMATS

Rather than having report and screen formats reside in separate definition files or tables, TAS-Plus puts them into the source program as a visual text map to be compiled each time the procedure is. This is a natural convention that supports rapid development of applications with a good visual layout.

The user enters screen and report definitions with a **\s** or a **\r**, followed by text and the ampersands (&), which act as field locators. If a screen is being defined, the text appears on the screen as prompts or labels; for a report, the text is printed. The ampersands define the start of each entry field in the case of screens and the printed fields in the case of reports (see figure 4). The fields are specified in a list at the end of the screen or report, between the second and third backslashes, in left-right, up-down order. The user must be sure to leave only one space between the **\s** and the screen name.

Boxes are written to screen with a function call, **pbox( )**, whose arguments are the coordinates of opposed corners; hence, they require a little care and patience to get correct. Of course, boxes and other designs can be entered directly into the source using an editor that supports eight-bit ASCII characters.

A screen that displays any fields in record buffers can be mounted while executing a TAS-Plus program. This is a

FIGURE 4: *Report Format*

```
\r report
          CONTENTS OF FILE SCZ
&           &          &   &    &          &
                                Page #   &
SCZ.STATE             SCZ.CODE  SCZ.LZIP  SCZ.UZIP
-------------------   --------  --------  --------
&                     &         &         &
Total number of records printed: &
\
wkday mnth aday yr atime ampm
pnum
scz.state scz.code scz.lzip scz.uzip
nrec
\
```

TAS-Plus report (and screen) formats are included in the source program.

convenient way both to debug a program and to monitor its progress through a long task. If a task requires many minutes or even hours to complete, a realtime display of the activity is most reassuring. A slight performance penalty is exacted for this display. The delay is caused by the program's checking the screen field table for each field to see whether or not it should be displayed. For most production applications, the display of the information probably saves time over the long run, because it can forestall inappropriate and destructive behavior by impatient users. People love to watch the numbers change; the entertainment value should not be underestimated.

TAS-Plus can defeat its internal limitation of showing only one record at a time from a given table through the use of temporary field arrays and memory areas. In the browse program, TASBRWSE, temporary fields can be displayed in addition to file record buffers.

The function **enter( )**, which is used to enter data through a screen, can specify a mask. At present this mask is very simple-minded; it is not really a mask but a filter that allows only certain characters to be entered. It does not provide justification or force entry, nor does it have formatting characters, such as the / and – in a phone number. With a real mask, the user could enter a phone number as *###/###–####*. In order to get a 10-digit phone number to display in a legible fashion, with TAS-Plus three additional overlay fields had to be defined within the number to split it into the area code, exchange, and number. This is a grave inconvenience in a general purpose data manager. All acceptable characters must be explicitly listed in the mask, which may be saved in a system table that is defined by the user. Business Tools plans to improve the mask function.

TAS-Plus does not perform any dynamic sorts. Programs that print data in a particular order must do so by an intelligent use of existing keys.

Report definitions in a file may resemble screen definitions, but, as might be expected, the two are used quite differently. TAS-Plus refers to each line of the report definition by number and keeps track of what text and which fields are part of that line. Reports are printed explicitly line by line with the function **pfmt( )**; format lines can be printed in any order and as many times as desired. No provision is made for visibly numbering the report format lines; they must be counted out.

One weakness of TAS-Plus's printing functions is the inability to format the data for output either in a screen or a report. The full length of the field is always printed exactly as it is defined in the data dictionary. To print it out in another form, the user first must define special temporary fields, copy the data to them, and then print these temporary fields instead.

Placing the field locators too close together—that is, not allowing enough spaces to display or print the full length of the field—produces unpredictable results. Screens that were tested for this review behaved satisfactorily with the latest version of TAS-Plus. Reports usually forget about the field whose locator lies within the reach of a preceding field. Remaining fields on the line may also be forgotten. The results seem to depend on the lengths and types of the fields involved. Error messages are never shown for these mistakes.

Producing neat multipage reports is difficult. Generation of footers and the elimination of widows and orphans must be coded manually. The TAS-Plus manual says nothing about these matters and provides no examples.

ADDED ATTRACTIONS

DOS commands can be run and other programs can be executed from within a TAS-Plus program. In addition, TAS-Plus allows the developer to save as many as eight screens to numbered memory buffers and redisplay them using the simple commands **saves(n)** and **redsp(n)**. The developer then can run an application with instantaneous screens. The instructions for the **saves( )** command in the developer's manual are incorrect. Contrary to what the manual states, adding 20 or 40 to the buffer number specified in the **saves( )** command is not required.

Data stored in memory storage locations can be displayed through the

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command **dispm()**. The manual provides no motivation for this command, nor any instruction on how to use it properly in a program. A few examples of its use are found in the TAS-Plus editor and browser source. For other commands that operate on data in memory buffers, "memory pointer update" and "memory space update," the manual is similarly silent. Examples of their use are confined to the editor source.

Another TAS-Plus function performs a wild-card search for file names on a specified drive and directory. Matching file names are returned in a field. If a match occurs, the user can then search for the next one. This function is particularly useful for managing error control, for building more flexibility into an application, and for creating dynamic menus.

FOR THE END-USER?

Only end users who are programmers or who have programming support should consider buying TAS-Plus independently. All others should buy the program from a VAR who can support it. Business Tools simply does not have the resources to provide step-by-step assistance if a user has a serious problem. TAS-Plus is thus a data manager for the self-reliant.

TAS-Plus provides good facilities for controlling program flow. Developers can write master screens for their application, so that the end user will never see TAS-Plus itself. A large amount of data entry validation and interactive flow control can be programmed, complete with help messages for each field in context. The thoughtful programmer can manage to maintain control of the data at least under normal assault by the user.

TAS-Plus does not have an audit trail for backing out bad transactions or any automatic data recovery facilities. Users who need support in the data manager for data integrity are advised to use programs such as PROGRESS or ORACLE that specialize in providing these types of facilities.

TAS-Plus has a password field type that is virtually undocumented except for a demonstration in the tutorial. The user codes the password test into the sales menu program as an **if** test. The correct password, *IBM*, is entered as a string constant to compare to PASSWORD. Using an editor anyone is able to go into the compiled program, SLSMNU.RUN, and find the magic word right after the password entry prompt. Using a date for a password might be a bit more clever, but TAS-Plus supports only alpha and numeric constants, and a password date entry could not be made to work during this review. Business Tools does not plan to encrypt passwords in future releases.

SHORT ON DETAIL

The documentation for TAS-Plus is a single volume of 356 pages, plus 3 pages of errata. A supplemental 60-page volume is supplied with the developer's version. A tutorial section takes the reader step-by-step through a very simple application, using the most important modules of the program. A reference section gives definitions of all the TAS-Plus commands in alphabetical order and attempts to describe, or allude to, what the major program modules do. Numerous typographical and factual errors betray the haste in which the manual was composed.

Only the simplest TAS-Plus commands are shown in the tutorial—and in their simplest forms. The same steps are repeated in excruciating detail again and again, as if the reader is unable to retain the slightest bit of knowledge from one page to the next.

The description of data types illustrates some of the problems with the manual. To determine the precise difference between the long and short date types, the author went on an extended treasure hunt through the manual. Despite the many trails and hints, no treasure was found. Only experimentation yields acceptable results. The time data type is also undefined.

Command definitions in the reference section leave the reader with fuzzy syntax, and the technical discussions of TAS-Plus can charitably be called perfunctory. The commands are presented within little black boxes; for many of them, however, the manual does not explain what goes in or what comes out or what change to TAS-Plus is produced by the command.

The large amount of source code supplied is entirely uncommented. Arcane features of the language are used in a manner that is very difficult to follow. Even for the experienced programmer, the mastery of TAS-Plus will be a slow and painful process.

The biggest initial obstacle to the programmer is the superficial coverage of the algebraic form of the TAS-Plus language. The only documentation is in a few pages of the supplemental reference guide for the developer's version; it lists the commands with argument meanings replacing actual arguments.

No precise definitions of actual arguments are given in the guide. For ex-

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ample, **save record** in the coded form is translated only as **save (filename, confirm, clear buffer, goto label)**. The manual does not state if a value must be specified in each argument place, nor does it tell the user how to confirm and clear the buffer. Another example: **screen lock/unlock** (which should be **screen lock/unlock/redisplay**) is translated as **scrn (what to do)**. What to do, indeed. The user can guess or use a text editor to look through the provided source for some representative **save** commands. The ambitious might want to use one of the public domain GREP utilities to build a library of examples of each command (see "Matching Regular Expressions," Programming Practices, Jon Forrest, May 1986, p. 191). Several of the more interesting commands are not used at all in the 275KB of source provided with the developer's version. The more arcane commands are embedded in complicated uncommented source.

Although this documentation is a stunning advance over that for TAS, it still has serious defects that are the result of hasty writing and production. A few surprising features exist in TAS-Plus that could be fatal to a developer's programs, but their mention is so underplayed in the manual that even a careful reader might miss them. Business Tools says that it is planning to produce a separate technical manual for developers—at some future time. A simple function key template for TAS-Plus also would make a great, inexpensive addition to the package.

Business Tools has begun to expand its support department and does seem to recognize deficiencies in its product. At present, however, only the program author seems willing to admit the existence of bugs, and only he seems to understand serious malfunctions when they occur. He can probably fix bugs faster than any one individual can find them, which bodes well for the future of this program.

SORTING THE SAMPLE

The sample application developed by the staff at *PC Tech Journal* (see "Evaluating Data Managers as Development Tools, Julie Anderson, August 1985, p. 46; also available for downloading on PCTECHline) imposes a set of impartial standards on the evaluation of the functionality of the data managers reviewed in this series. The sample application includes the importation of delimited ASCII data into a previously defined database; ad hoc queries on this data; a specific data entry screen with validation; several specific reports; and a set of performance benchmarks.

Import and export of foreign ASCII files is described in two appendices to the TAS-Plus manual. Delimited, fixed-length, and text files can be read or written only with a program especially designed for the job. The capability for changing the comma delimiter does not exist in TAS-Plus, either in reading a delimited file or in writing it. Imported ASCII fields that are too long for the field in the target file are truncated without generating an error message.

Fields specified in the schema as uppercase are automatically entered as such through data entry screens. However, the import functions of TAS-Plus do not do this work unassisted. The user must use **upcase( )** on the fields before saving in the TAS-Plus file.

Most dates must be delimited for TAS-Plus to import them, because the TAS-Plus routine that converts strings to the date types (long and short) only works when two characters each are given to the month and the day. The following dates are imported correctly, whether enclosed in quotes or not:

01-02-1986, 1/ 2/1986, 1- 2/86

but the following would not be:

1-2-1986,1/02/1986,1/02/86,01-2-86

No error message is produced when one of the incorrectly formatted dates is imported, but the field contains a nonsense date. Because it is impossible to govern the format of all dates to be imported, this deficiency of TAS-Plus's data conversion must be considered serious.

When importing fixed-length records, a problem can arise that causes bizarre displays when the user tries to examine the imported file. When opening a non-TAS file, the CR-LF pair (if present) must be included in the buffer length, or TAS-Plus will scatter CR-LFs into fields. This foible is mentioned in appendix IV of the manual, but is not in the reference guide under the **open non-tas file** command.

Only one of the seven ad hoc queries for the sample application could be made with the report generator without editing the source code for the generated report programs. The changes to the source for the other six queries were quick and easy.

The three main reports caused a great deal of difficulty, because of problems with the implementation of structured programming language. Once these problems were resolved, the reports, written to be as structured as TAS-Plus allows, worked well.

TABLE 1: *Benchmark Results*

BENCHMARK TASK (secs)[a]	**TAS-Plus TIME**	**AVERAGE TO DATE**
Add 900 records to an empty database table	335	177
Index table on two fields (7 bytes)	100[b]	48
Document and tally codes from one column	40	53
Mass change of one column (28 rows of 900)	14	21
Extract selected records to create a text file	2	11

[a] *All benchmarks were run on an IBM PC/AT (6 MHz) with 640KB memory. The tests were run in an 8MB partition on a CMI 20MB disk under DOS 3.0.*
[b] *Time required to index with the two fields as the only key.*

TAS-Plus is slow at data import, but respectably fast at the other benchmarks.

No attempt was made to generate the sample data entry screen with the TAS-Plus screen generator. The screen generator does not permit changes at will to the order of entry of the fields displayed on the screen. This screen was written in the algebraic form of TAS-Plus source, which allowed complete control over the order of entry and other aspects of screen behavior. Various traps and validations were used to make it relatively trouble free.

MIXED REVIEWS

PC Tech Journal specifies five benchmarks, which have been run for all database managers in this series. The results for TAS-Plus are shown in table 1. All performance benchmarks have been run on the same 6-MHz AT in the same fresh disk partition. TAS-Plus is slow at data import, but it is respectably fast at all of the other benchmarks, including export, even though it, too, is run with interpreted token code.

For the first benchmark, the 900-record AUTHOR file was imported from a comma-delimited ASCII file and simultaneously indexed on the full name of the author. Mounting a screen that showed the current record number imposed a 10-percent time penalty above the listed benchmark time. Looking up the state postal codes in a separate file of the 58 valid codes imposed an additional 20-percent penalty. Leaving the postal code file open, but not using it, produced the same penalty as mounting the screen. Curiously, these two penalties are not additive; mounting the screen and leaving the unused file open at the same time produced the same penalty as either one alone.

The second benchmark, adding to the author name index a seven-character index composed of the state postal/zip code, could not be run with TAS-Plus, because the indexes are part of the file definition; if the file is to be keyed on any index, it must be keyed on all simultaneously. The time shown in the table is the time required to index the file once it has been redefined to have the state postal/zip code as the only key.

For the third benchmark, tallying the numbers of occurrences of each state postal code in the author file, TAS-Plus was near the average of all data managers tested so far in this series. The fourth benchmark, which required the location and modification of all records with CO for the postal code, TAS-Plus began to move with a faster crowd, although it still does not approach the fastest. On the last benchmark TAS-Plus showed very snappy performance. No data manager tested so far has been measurably faster.

TAS-Plus is certainly neither the most powerful nor the easiest data manager to use. The glaring deficiencies in the documentation often make use of this product a game of trial and error. Its large number of bugs indicate that the product was released prematurely.

However, TAS-Plus is at least functional and it is the lowest priced of the data managers reviewed so far in this series. As the work of a single programmer, it is particularly impressive. The difficulties encountered in using TAS-Plus as a stand-alone product are considerably mitigated when the task at hand is the modification of an existing accounting system. The basic system is provided and a sufficient number of examples of functioning code are available. Professional programmers seldom write something from scratch when they can adapt existing source code, and TAS-Plus does offer access to a large quantity of source. Despite its problems and limitations, a reasonable case can be made for taking a chance on this product.

Jim Roberts, Ph.D., is an astrophysicist from California with a special interest in data management products.

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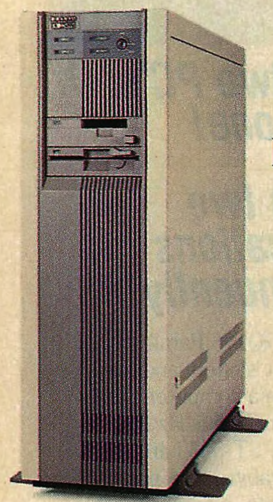

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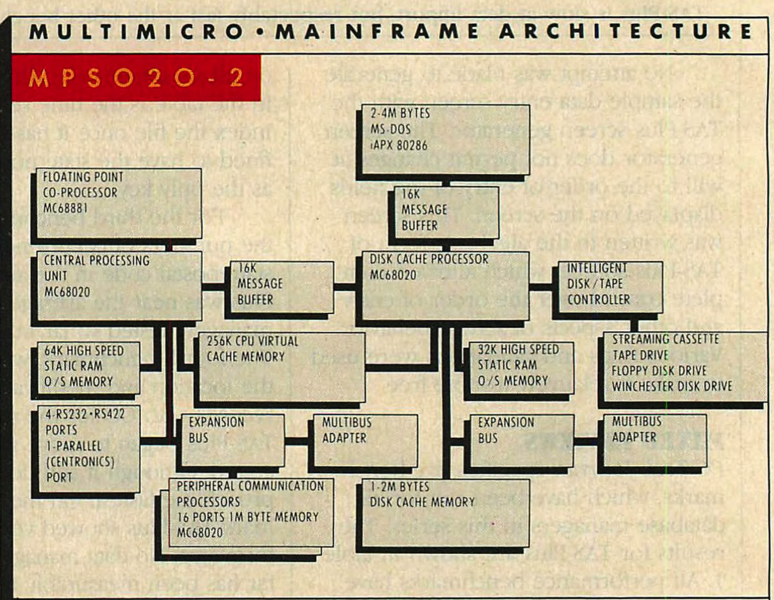

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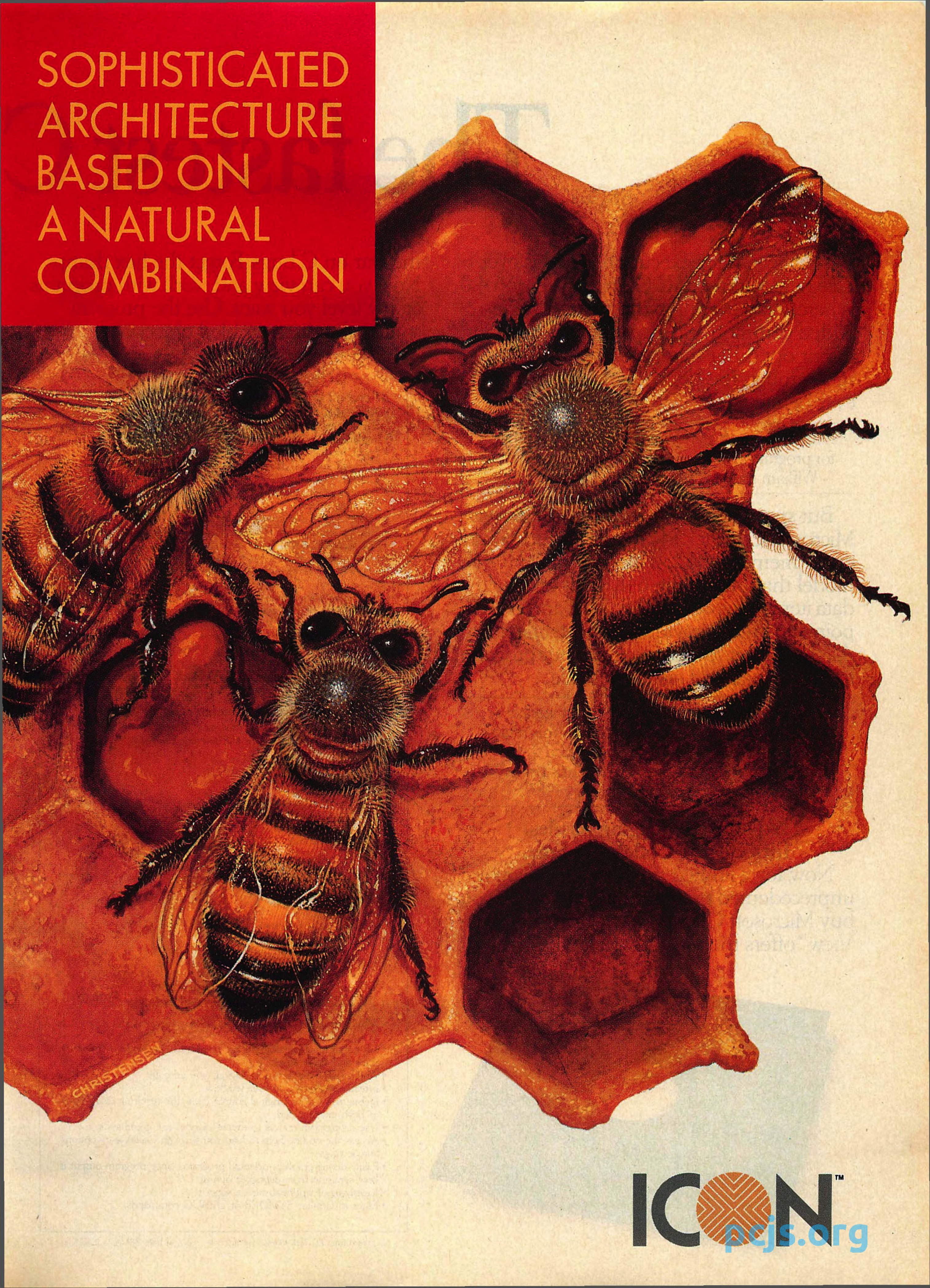
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	Microsoft C 4.0	Lattice C 3.0	Computer Innovation C 2.3	Aztec C86 3.2	Wizard C 3.0
Sieve of Eratosthenes (register)	82.9	151.4	172.3	88.0	91.9
Copy Block	86.9	231.7	199.0	123.8	189.5

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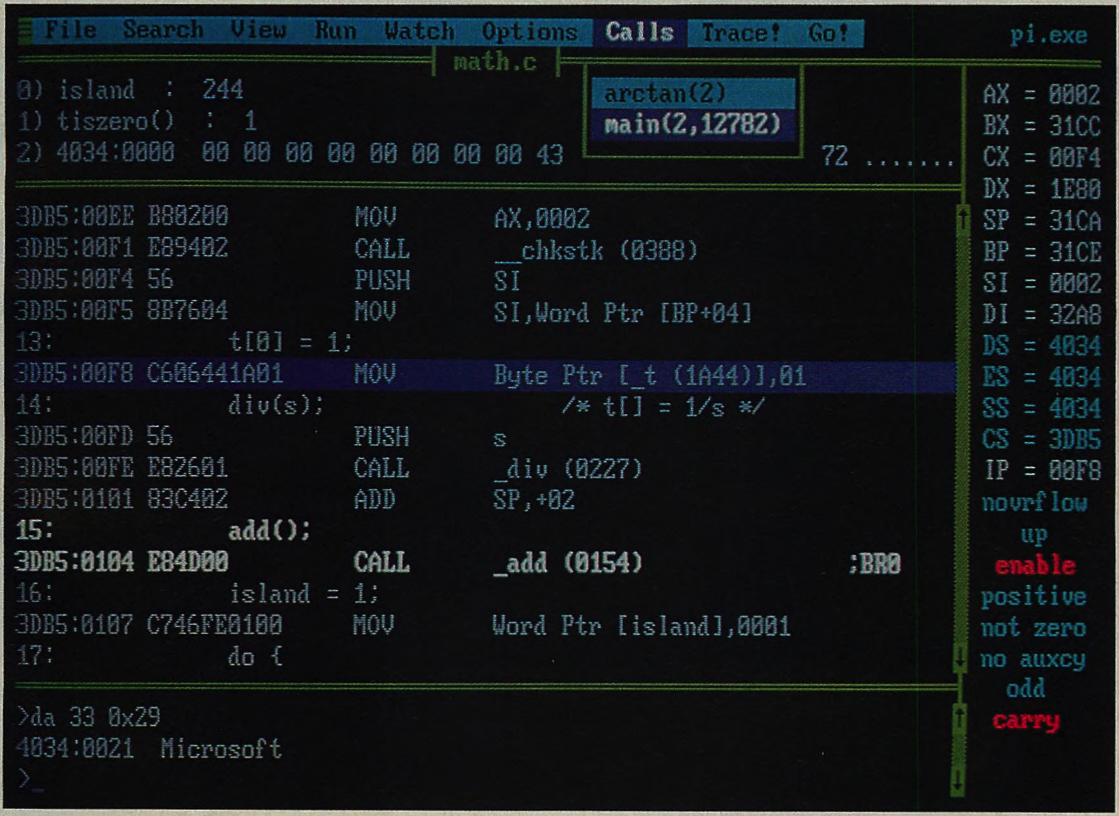

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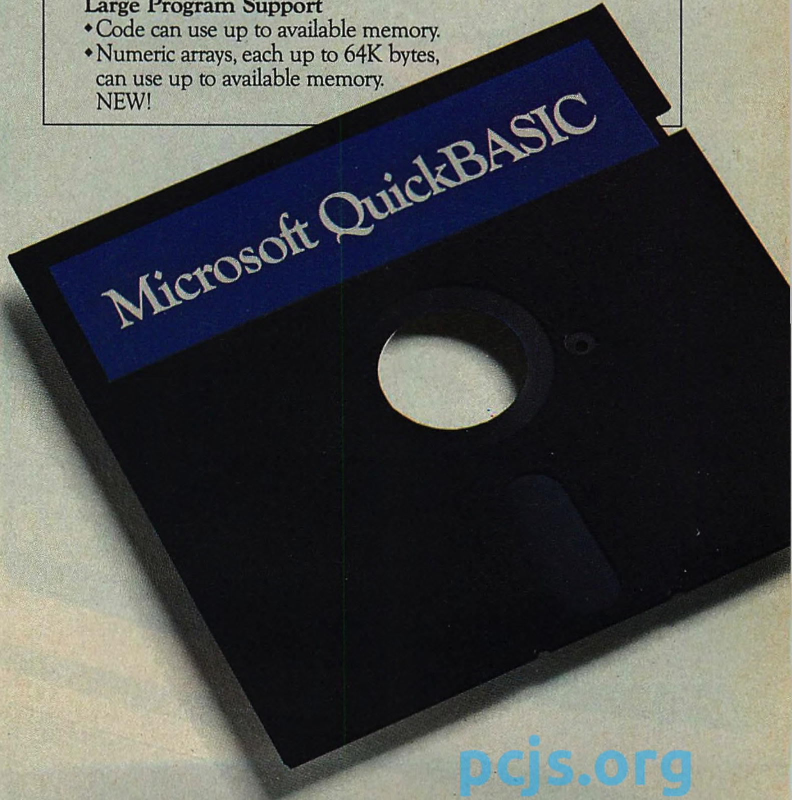

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Dynamic Memory Management

By using DOS memory management functions, memory for data and input/output buffers can be allocated outside the program's segment at runtime.

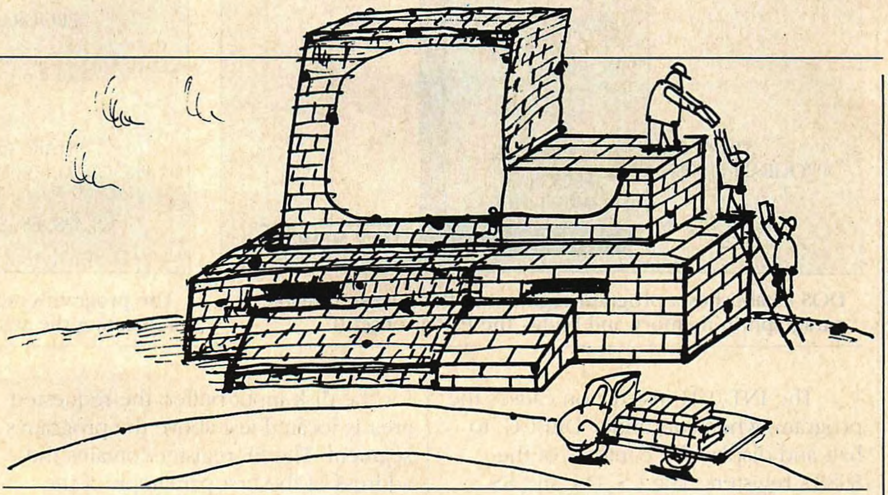


ILLUSTRATION • MACIEK ALBRECHT

When programs require large amounts of memory for data or input/output buffers, the memory is usually reserved by using the DB (define byte) memory directive. Consider, for example, the program READDIR1.ASM (listing 1). This program reads the directory on the diskette in drive A: into the memory area that is labeled DIRECTORY_BUFFER. For a double-sided diskette with nine sectors per track, the buffer size requirement is:

7 sectors * 512 bytes per sector = 3,584 bytes.

Although the program in listing 1 contains only 11 executable instructions, the .COM file produced when it is assembled, linked, and converted using the EXE2BIN utility is 3,606 bytes long. This happens because the statement:

DIRECTORY_BUFFER DB 3584 DUP (?)

causes 3,584 bytes of nulls to be included in the .COM file. In addition to wasting disk storage, the 3,584 bytes of nulls are copied from the disk to memory each time the program is loaded, which slows down system operation.

By using DOS memory management functions, memory requirements for the program can be allocated outside of the program's segment at runtime. The examples used are small programs that read the directory from drive A:, but the memory management techniques can be used in applications requiring a large amount of memory.

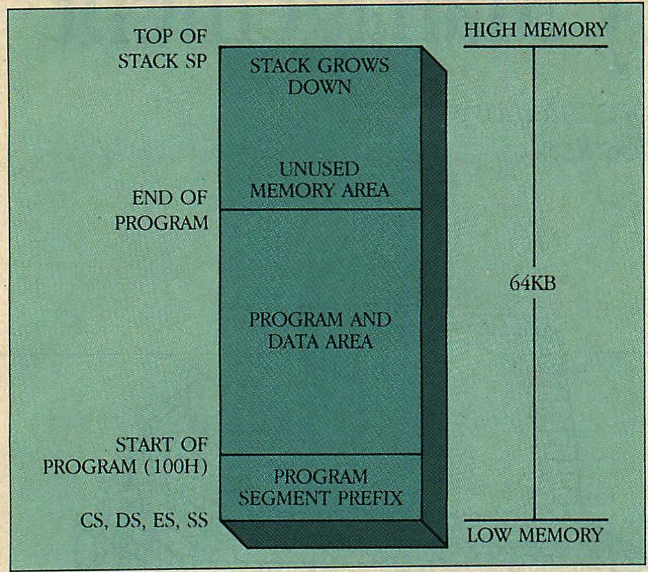
When DOS loads a program into memory, all of the available memory is allocated to the program. Obtaining an area of memory to use for data or as an input/output buffer is a two-step procedure. First, DOS must be told to reduce the amount of memory allocated to the program by calling function 4AH. Second, a request is made to DOS to allocate the additional memory required by calling function 48H. DOS returns the segment of the newly allocated memory block in the AX register. If sufficient memory is not available to satisfy the request, DOS returns with the carry flag set, error code 8 in the AX register, and the size of the largest block of memory available (in paragraphs) in the BX register; the application program can either exit or request a smaller block. In the examples shown, an exit to DOS is made. However, program requirements permitting, the number of sectors to be read can be reduced to fit the available memory, and the same memory area can be used to read the directory iteratively. READDIR2.ASM (listing 2) performs the same function as the program in listing 1. The .COM file, however, is only 58 bytes long—a saving of more than 3,000 bytes (equivalent to six sectors of disk space).

When DOS loads a .COM file into memory it establishes the program's segment at the lowest available paragraph boundary. The first 256 (100H) bytes of the program's segment are used for the program segment prefix (PSP). The binary file is then copied from disk to memory beginning at offset 100H. Figure 1 contains a diagram of the program segment for a .COM file after the program has been loaded into memory. The loader puts the address of the start of the program's segment into the CS, DS, ES, and SS registers. The stack pointer (SP register) is set to the end of the program's 64KB segment and a word of zeroes is placed on the top of the stack.

Listing 2 begins by reducing the memory allocated to the program. Because a .COM file occupies 64KB when loaded, a request is made to reduce the amount of memory allocated to the program to 64KB. DOS function 4AH is called by loading the segment address of the program's segment into the ES register and the requested block size, in 16-byte paragraphs, into the BX register. The loader places the address of the program's segment into the ES register. Because the ES register is not modified in this example, only the BX register must be loaded. The value of 4,096 paragraphs corresponds to 64KB. If the carry flag is set upon return from function 48H, then an error has occurred and the program is exited via a jump to ERROR_EXIT_1.

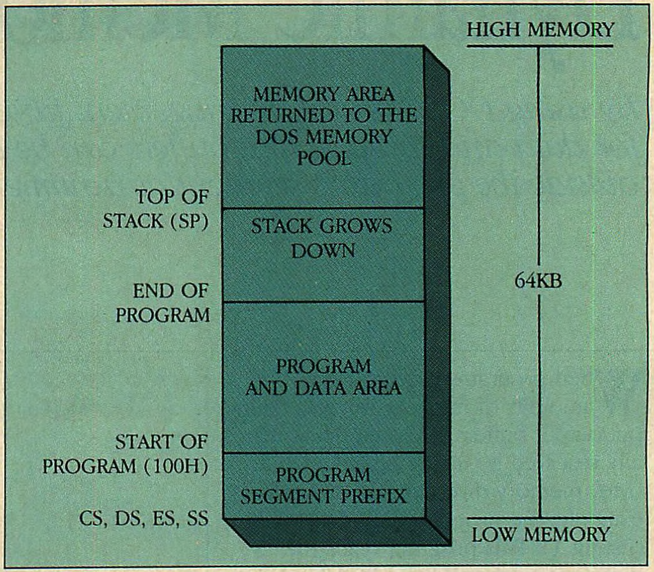
The program requests DOS to allocate 224 paragraphs (3,584 bytes) of memory. Function 48H is called by loading the desired memory block size into the BX register. If the carry flag is set, an error has occurred and an exit is taken via a jump to ERROR_EXIT_1. Returning with the carry flag not set, the AX register contains the segment of the allocated memory block.

FIGURE 1: *Program Memory Map*



DOS establishes a program segment at the lowest available paragraph in memory and builds the PSP at offset 0.

FIGURE 2: *.COM File with Stack Relocated*



The program's memory requirements have been reduced by relocating the stack closer to the program.

The INT 03H instruction causes the program, when run under DEBUG, to halt and display the contents of the 8088's registers. The CS, DS, and SS registers all contain the segment at which the program was loaded. The SP register contains FFFEH because DOS pushed a word of zeroes onto the stack when the program was loaded. A RET instruction will then cause an intrasegment jump to the address CS:0, which contains an INT 20H (program terminate) instruction. Because the memory allocated to the program has shrunk to 64KB and DOS has allocated memory for the disk input buffer, the requested area is located just above the program's segment. The ES register contains the address of the first paragraph of the block allocated.

In order to maintain the addressability of the data in the program's segment through the DS register, the ES register is used to address the data in the newly allocated memory block.

The diskette directory's sectors are now ready to be read into the newly allocated memory block by calling DOS interrupt 25H (absolute disk read), which loads the diskette sectors into the area indicated by DS:BX; however, the ES register is needed to address the area of memory that will contain the data from the diskette directory. This problem can be overcome by pushing the DS register onto the stack and moving the contents of ES to DS prior to reading the diskette sectors. INT 25H saves the flags on the stack and leaves them there upon returning. Thus, the user must pop the stack to retrieve the DS register that was pushed onto the stack prior to the INT 25H call. The POPF instruction in listing 2 restores the flags after the read operation. DS

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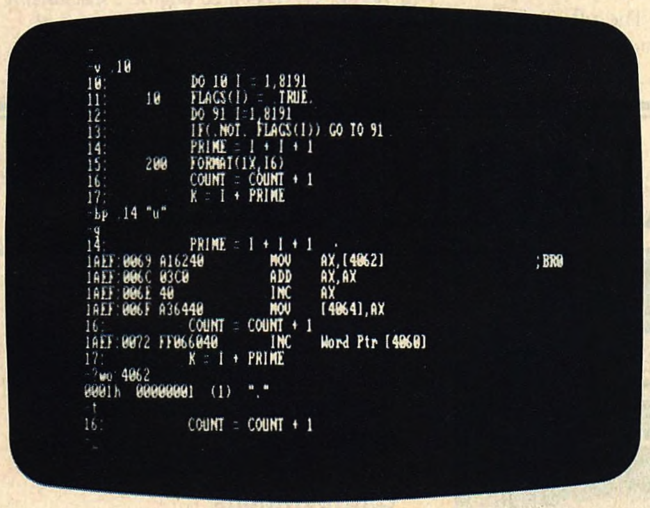

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can then be restored, and the stack pointer will be in position for a RET instruction. The stack does not grow if many calls are made to INT 25H.

The data in the newly allocated memory block can be addressed with the segment override prefix ES:. For example, to move the first byte of data from the allocated memory block to the AL register, insert the coding:

```
XOR    SI,SI
MOV    AL,ES:[SI]
```

Before the program exits to DOS, the newly allocated block of memory should be released back to the DOS memory pool. This is done by calling function 49H with the segment of the block to be returned in the ES register. DOS does not release memory allocated by application programs when the program exits. If many memory allocations are made, the memory pool may become too fragmented for DOS and a system reset will be needed.

Because the ES register has been changed, care should be exercised when using any of the 8088's string move and/or string compare instructions. These instructions expect the ES register to address the destination segment. The DS and ES registers can be saved on the stack to preserve their contents during string operations.

The foregoing procedure reduces the size of the .COM file on disk. However, the memory requirements of the program have increased because of the allocation of memory outside of the program's segment. If the availability of memory is a constraint, the amount of memory required by the program may be reduced by relocating the stack top closer to the program.

Figure 2 is a memory map of a .COM program with its stack relocated. READDIR3.ASM (listing 3) is an example of a program that uses this method to reduce memory. Extreme care should be exercised when relocating the stack. First, sufficient space should be left for the stack to expand downward without overwriting any of the program's code. Second, the linker may concatenate one or more object modules to the end of the program, which could be overwritten by the stack. Assuming that no modules will be concatenated to the program by the loader and that 128 words will provide sufficient space for the stack, the label END_OF_PROG in listing 3 is used to find the offset of the end of the program. The offset of the new stack top is located by adding 256 bytes to the offset of the label END_OF_PROG. A word of zeroes is then pushed onto the stack. The program's memory allocation can then be reduced to a size large enough to accommodate the program with the relocated stack. The remainder of listing 3 is functionally equivalent to listing 2.

The INT 03H instruction causes the program, when run under DEBUG, to halt and display the registers. The CS, DS, and SS registers all contain the same values seen earlier. The SP register now contains a lower offset because the stack has been relocated downward, closer to the beginning of the program's segment. The ES register contains the address of the paragraph just above the stack pointer. The memory required is equal to the offset of the stack pointer (plus 2 for the word of zeroes that was pushed onto the stack) rounded up to the next paragraph boundary (592 decimal), plus the 3,584 bytes requested for the disk input buffer (plus 16 bytes for DOS's control information for the additional memory block) for a total of 4,192 bytes.

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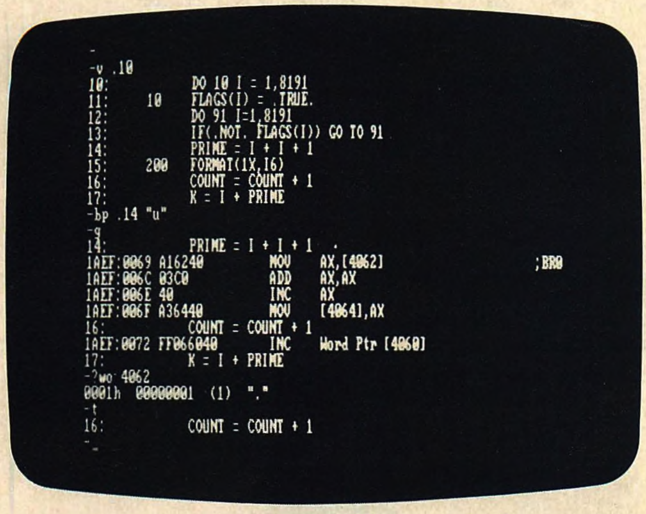

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LISTING 1: READDIR1.ASM

```
; This program reads the directory from the diskette in drive A
; into the memory area at DIRECTORY_BUFFER.  For the sake of
; simplicity no console input or output functions are performed.
;
CODESEG SEGMENT PARA   PUBLIC   'CODE'
        ASSUME  CS:CODESEG,DS:CODESEG,ES:CODESEG,SS:CODESEG
;
        ORG     0100H
;
BEGIN:  JMP     READ_DIRECTORY
;
; *********************** Data Definitions ***************************
DIRECTORY_BUFFER        DB        3584 DUP (?)
;
; ***********************  Main Procedure  ***************************
READ_DIRECTORY:
;
; Setup the registers for absolute disk read
;
        MOV     AL,00H            ; Drive A
        MOV     BX,OFFSET DIRECTORY_BUFFER    ; Point to the beginning
                                              ;    of the memory area
        MOV     CX,0007H          ; 7 Sectors to be read
        MOV     DX,0005H          ; Start at sector 5
        INT     25H               ; Absolute Disk Read Interrupt
        JC      ERROR_EXIT        ; Quit if there was an error
        POPF                      ; Restore the user flags
        RET                       ; Return to DOS
;
; Error return point -- error fixup or messages can go here
;
ERROR_EXIT:
        POP     DI                ; Throw away the user flags
        RET                       ; Return to DOS
;
CODESEG ENDS
; *******************************************************************
        END     BEGIN
```

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LISTING 2: READDIR2.ASM

```
; This program reads the directory from the diskette in drive A.
; The input buffer area is outside the program's segment and is
; obtained from the DOS memory pool by calling DOS Function 48H,
; after calling DOS Function 4AH to "shrink" the memory allocated
; to the program.  For the sake of simplicity no console input or
; output functions are performed by this program.
;
CODESEG SEGMENT PARA    PUBLIC   'CODE'
        ASSUME  CS:CODESEG,DS:CODESEG,ES:CODESEG,SS:CODESEG
;
        ORG     0100H
;
BEGIN:  JMP     READ_DIRECTORY
;
; ********************** Main Procedure ***********************
READ_DIRECTORY:
;
; "Shrink" the program memory allocation by calling DOS Function 4AH
;
        MOV     BX,4096         ; 64K for the program
        MOV     AH,4AH          ; DOS function
        INT     21H             ; Function request
        JC      ERROR_EXIT_1    ; Quit if there was an error
;
; Request DOS to allocate a block of memory for the disk input area
;
        MOV     BX,224          ; Room for 7 sectors
        MOV     AH,48H          ; DOS function
        INT     21H             ; Function Request
        JC      ERROR_EXIT_1    ; Quit if there was an error
        MOV     ES,AX           ; Move segment from AX to ES
;
; Set breakpoint for DEBUG so that the registers can be examined
;
        INT     03H                     ; DEBUG breakpoint
;
; Setup DS for the Absolute Disk Read
;
        PUSH    DS                      ; Save DS
        MOV     AX,ES                   ; MOVE the contents of ES to DS
        MOV     DS,AX                   ;    via AX
;
; Setup the registers for the Absolute Disk Read
;
        MOV     AL,00H                  ; Drive A
        XOR     BX,BX                   ; Point to the beginning
                                        ;   of the memory area
        MOV     CX,0007H                ; 7 sectors to be read
        MOV     DX,0005H                ; Start at sector 5
        INT     25H                     ; Absolute Disk Read Interrupt
        JC      ERROR_EXIT_2            ; Quit if there was an error
        POPF                            ; Restore the user flags
        POP     DS                      ; Restore DS
;
; Free the allocated memory block prior to returning to DOS
;
        MOV     AH,49H                  ; DOS function
        INT     21H                     ; Function Request
        RET                             ; Return to DOS
;
; Error return without popping the stack
;
ERROR_EXIT_1:
        RET                             ;Return to DOS
;
; Error return with popping the stack
;
ERROR_EXIT_2:
        POP     DI                      ; Throw away the user flags
        POP     DS                      ; Restore DS
;
; Free the allocated memory block prior to returning to DOS
;
        MOV     AH,49H                  ; DOS function
        INT     21H                     ; Function Request
        RET                             ; Return to DOS
;
CODESEG ENDS
;
; ******************************************************************
        END     BEGIN
```

LISTING 3: READDIR3.ASM

```
; This program reads the directory from the diskette in drive A.
; The top of the program's stack is relocated downward in memory.
; The memory allocation for the program is reduced to a size just
; large enough to accommodate the program and its stack.  The
; memory area for the diskette input buffer is located just above
; the top of the stack. The total memory required by the program
; buffer is less than the 64KB memory required by a .COM program.
;
CODESEG SEGMENT PARA    PUBLIC   'CODE'
        ASSUME  CS:CODESEG,DS:CODESEG,ES:CODESEG,SS:CODESEG
;
        ORG     0100H
;
BEGIN:  JMP     READ_DIRECTORY
;
; ********************** Main Procedure ************************
READ_DIRECTORY:
;
; Relocate the stack downward in memory
;
        MOV     AX,OFFSET END_OF_PROG  ; Pointer to the program end
        ADD     AX,256                 ; Allow 128 words for stack space
        MOV     SP,AX                  ; Move new stack pointer offset to SP
        XOR     AX,AX                  ; Push a word of zeroes onto the stack
        PUSH    AX
```

```
;
; SP now contains the program length minus 2
;
        MOV     BX,SP           ; Move SP to BX
        ADD     BX,02H          ; Add 2
        MOV     CL,04H          ; Divide by 16 to convert from
        SHR     BX,CL           ;    bytes to paragraphs
        INC     BX              ; Add one paragraph for safety
;
; "Shrink" the program memory allocation by calling DOS Function 4AH
;
; BX contains the required amount of memory in paragraphs
;
        MOV     AH,4AH          ; DOS Function
        INT     21H             ; Function Request
        JC      ERROR_EXIT_1    ; Quit if there was an error
;
; Request DOS to allocate a block of memory for the disk input area
;
        MOV     BX,224          ; Room for 7 Sectors
        MOV     AH,48H          ; DOS Function
        INT     21H             ; Function Request
        JC      ERROR_EXIT_1    ; Quit if there was an error
        MOV     ES,AX           ; Move segment from AX to ES
;
; Set breakpoint for DEBUG so that the registers can be examined
;
        INT     03H             ; DEBUG breakpoint
;
; Setup DS for the Absolute Disk Read
;
        PUSH    DS              ; Save DS
        MOV     AX,ES           ; Move the contents of ES to DS
        MOV     DS,AX           ;     via AX
;
; Setup the registers for the Absolute Disk Read
;
        MOV     AL,00H          ; Drive A
        XOR     BX,BX           ; Point to the beginning
                                ;     of the memory area
        MOV     CX,0007H        ; 7 sectors to be read
        MOV     DX,0005H        ; Start at sector 5
        INT     25H             ; Absolute Disk Read Interrupt
        JC      ERROR_EXIT_2    ; Quit if there was an error
        POPF                    ; Restore the user flags
        POP     DS              ; Restore DS
;
; Free the allocated memmory prior to returning to DOS
;
        MOV     AH,49H          ; DOS FUNCTION
        INT     21H             ; Function Request
        RET                     ; Return to DOS
;
; Error return without popping the stack
;
ERROR_EXIT_1:
        RET                     ; Return to DOS
;
; Error return with popping the stack
;
ERROR_EXIT_2:
        POP     DI              ; Throw away the user flags
        POP     DS              ; Restore DS
;
; Free the allocated memory prior to returning to DOS
;
        MOV     AH,49H          ; DOS Function
        INT     21H             ; Function Request
        RET                     ; Return to DOS
;
END_OF_PROG     EQU     $
;
CODESEG ENDS
; ****************************************************************
        END     BEGIN
```

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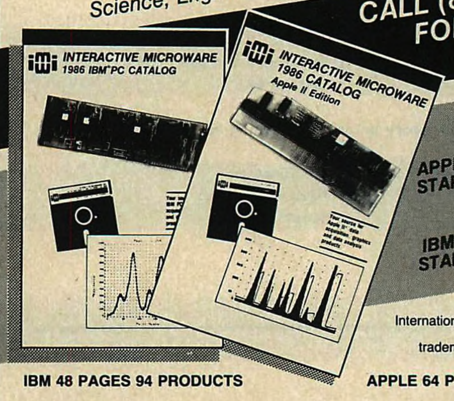

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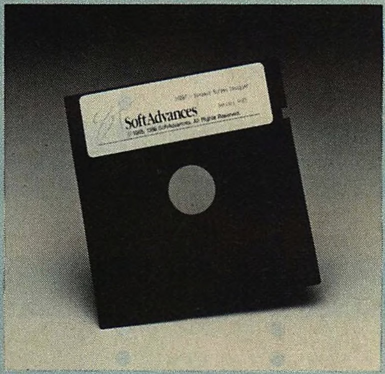


CIRCLE 345 ON READER SERVICE CARD

DSD87 is a symbolic debugger with a lot of power, but power that is not easily accessed. A dynamic screen debugger with 8087 support, DSD87's expressive macro language is ideal for complex tracing tasks, but its language syntax checking is minimal. (The product is offered without 8087 support as DSD86.) Although multiple windows may be opened and accessed, the windows are not labeled in the display, nor is a list of open windows available. In addition, the process of building macros or creating command files requires much reference to the manual.

In the accompanying table, DSD87 1.2 is compared with SYMDEB 4.0, Microsoft's extended version of DOS DEBUG. (Previously, DEBUG had been the point of reference in evaluating debuggers—see "Entomological Explorations," Steven Armbrust and Ted Forgeron, January 1985, p. 88.) SYMDEB is packaged with MASM 3.0 and later (see "Same Language, New Architecture," Ted Mirecki, October 1985, p. 48).

DSD87 is set apart from SYMDEB in three ways. First, the DSD87 display can be customized, and toggled from one arrangement to another with a single key press. It offers seven types of window: horizontal or vertical register, instruction, memory, stack, source, and user, as well as an 8087 window.

Each window can be opened or closed independently. When a window is opened, it is named, its position is set by row and column coordinates, and a start address is specified. Subsequent window commands use the name to reference the contents of the window. A line is reserved for command input at the bottom of the screen. The maximum number of open windows appears to be limited only by available memory. Switching among windows and refreshing of window contents is rapid.

Among the windows, the registers can be horizontal or vertical, but the stack display is vertical, with POPs off the top of the display column and PUSHes adding to the top. Multiple instruction windows can display different segments of code; these windows can track the trace of executed code. Lines of source code are displayed from the opening line to the end of the window. A source code window and instruction window may track executed code simultaneously. In the memory window, the display can be in byte, word, or doubleword format. The user window permits a formatted display of memory with embedded text. The 8087 window shows the contents of numeric coprocessor registers and flags.

Public symbols loaded in the map file appear in all appropriate windows. The instruction, memory, and source windows can be scrolled in several directions by user-defined commands.

DSD87's macro facility is a second capability unmatched in SYMDEB. Any command or previously defined macro can be used in a macro definition; a maximum of eight parameters is allowed. The most useful commands include a WHILE loop (called LOOP) and several conditional branch commands. Conditions checked include whether an argument is blank and whether it is true or false. Also part of the rich macro environment is a collection of read-only variables that make available the following operations:

- the location where the next permanent breakpoint occurs;
- the scan code, if a key is typed;
- the line in the source code that is currently executing;
- the segment and offset of the instruction following the current instruction;
- and the opcode of the currently executing assembly language instruction.

The opcode information lets the programmer set a breakpoint on a specific type of instruction. The segment and offset of the next instruction proves helpful in setting breakpoints after a CALL, INT, or LOOP.

Finally, the product's keyboard macro capabilities also distinguish it from SYMDEB. Both can combine multiple commands on a single line, but DSD87 permits assigning these command strings to a Ctrl-, Alt-, Shift-, or Function-key combination. The command may invoke a macro or a command file. An initialization file can be created and loaded at the start of DSD87 that contains commands binding keys to a set of user-tailored functions. (A similar capability is possible with SYMDEB by using a resident keyboard macro package, such as Borland's SuperKey.)

With the exception of some boundary condition bugs, DSD87 is solidly designed. It will, however, hang the computer if less memory than it needs is available. If the program loads, but it does not have enough room for debug code or map information, the ERROR IN INIT FILE message is issued. This same message resulted from several syntax errors that were made during trial macro and command file construc-

TABLE: *DSD87 versus SYMDEB*

FEATURE	DSD87 1.2	SYMDEB 4.0
Supports DEBUG commands	● [a]	●
Memory display by ASCII, word, double word	●	●
Memory display of short, long, or 10-byte reals	○	●
Enter memory in ASCII, word, double-word modes	○	●
Enter memory as short, long, or 10-byte reals	○	●
Expression evaluator	●	●
Scratch-pad registers	●	○
Load map file	●	○
Command-line invocation of multiple map files	○	●
Command-line invocation of command scripts	●	●
Redirection of input	●	●
Redirection of output	○	●
Swap between program display and debugger display	●	●
Support for second monitor	○	● [b]
Support for COM terminal	○	●
Escape to execute shell command	○	●
Source code display with assembly	●	●
Step execution by source line	●	●
Step over function or procedure calls	●	●
Source code browse	●	●
Display of function or procedure arguments	○	●
Set map segment origin (needed for using a MAP with resident code)	●	●
Examine symbol map	○	●
Set symbol value	○	●
Execution with temporary breakpoints	●	●
Sticky breakpoints set, clear, enable, etc.	● [c]	● [c]
Support for NMI break out button	●	●
Break by software INT 3	●	○
Support for 8087/287	●	●
Support for 80186/286 instructions	○	●
On-line help	○	●
User-defined display windows	●	○
Bind any command/command sequence to a single key	●	○ [d]
User-defined macro commands	●	● [b]
Macro command language	●	○

● = *Yes* ○ = *No*

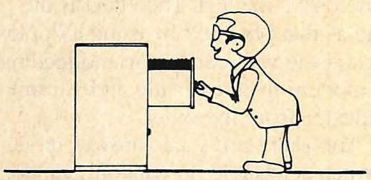
[a] *DSD implements all DEBUG commands either by identical commands or equivalent macros with one exception, logical sector read and write.*
[b] *By redirection*
[c] *DSD87 can enable 20 breakpoints; SYMDEB can enable 10.*
[d] *Without SuperKey*

Soft Advances' DSD87 is a powerful, solidly designed debugger with extensive macro facilities for defining various types of window and movement capabilities. Microsoft's SYMDEB, however, continues to offer some features that DSD87 does not: redirection, support of the 80286, a symbol map display, and shell escape.

tion. Obviously DSD87 offers little in the way of error reporting.

Three additional features would make this debugger easier to use: an on-line command summary; an on-line configuration summary including defined keys, macros, and windows; and a better manual. Its current documentation is unclear and difficult to follow. A command summary card would help in putting the powerful DSD87 features to work. Another hindrance is that the current symbol map is not displayed.

The DSD87 distribution diskette does contain three good sample programs with associated command files, and its system requirements are minimal: 64KB of memory and DOS 2.x or later. This debugger works well with monochrome, RGB, and composite



PRODUCT WATCH

black-and-white displays; however, screen attributes are not user controlled. If line number information is used for source code debugging, LINK 3.0 (packaged with MASM 3.x) is required for generating MAP files.

SYMDEB still offers some advantages: redirection capabilities, 80286 support, a symbol map display, and shell escape. It also allows multiple symbol maps to be loaded when the program is started, thus offering the benefit that both resident and transient code maps can be active. DSD87 allows only a single symbol map to be loaded at one time, a macro must be written to load another symbol map when a trace enters into resident code. Upon reentry into transient code, its symbol map has to be reloaded.

DSD87 is a powerful, solidly designed debugger. If DSD87 offered all of the features of SYMDEB in addition to its windowing, keyboard, and macro facilities, it would be a superb product. As it stands, it is questionable whether the added power is worth the investment unless the user has special tracing chores that require custom macros.

—STAN MITCHELL

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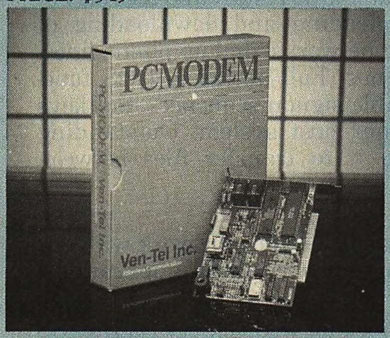
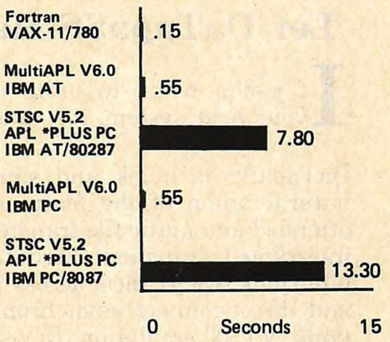


CIRCLE 347 ON READER SERVICE CARD

Ven-Tel has led the effort to provide full-function internal modems that fit comfortably in the short slots in some PCs. The Ven-Tel PC Modem Half Card uses proprietary LSI integrated circuits to achieve a low parts count and low power consumption. (See the original review of this modem in "Communicating from Within," Augie Hansen, September 1985, p. 60.) Its design has been



imitated by AST Research (in its Reach! modem) and others. Even Hayes has introduced a half-sized version of its 1200B internal modem.

The original review of the Ven-Tel modem was critical of its hardware documentation and of the poor sound quality of the built-in speaker. The speaker has not been changed, but other important aspects of the product have evolved considerably. The latest version of the PC Modem Half Card, which is several releases beyond the product reviewed previously, incorporates new hardware features and is supported by improved documentation and release 3.6 of Microstuf's Crosstalk XVI.

One noteworthy addition is that the user now can designate the modem for access as COM3 or COM4 in addition to the usual COM1 and COM2. Designation of the port is controlled by two switches on the modem board. The switch is set at the factory for COM2, and the companion software is set to use COM2 as the default. Most internal modems are preconfigured this same way. The assignment of COM2 as the default presumes that another serial port is already installed in the PC; if no other serial port is present (in the PC), the defaults must be changed to COM1.

The IBM PC family has since its introduction used hardware interrupt level 4 (IRQ4) for COM1 and level 3 (IRQ3) for COM2. Because the additional port assignments use hardware interrupt requests other than IRQ3 and IRQ4, circumstances arise for conflicting requests from other peripheral devices. Care must be exercised in configuring PCs with more than two serial ports, especially when hard disks and network interfaces are installed.

A jumper on the Half Card enables the modem to be used in slot 8 (which accommodates short boards only) in the PC/XT. This function previously was controlled by a switch, but was revised to use a set of jumpered pins in order to free the switch for the aforementioned port-selection duties.

The documentation is a Crosstalk XVI-style user's manual that now includes chapters and appendices describing hardware installation and testing procedures, line connections, warranty terms and conditions, and FCC-required information. A detailed treatment of modem commands, registers, and modem operation has been added since the last review.

Ven-Tel reports that it has added a call-progress reporting feature so that communications programs can provide suitable messages regarding the presence or absence of dial tone and status of the line (off-hook, ringing, busy, no answer, and so on). However, neither the user manual nor the supplied software addendum documents this feature. The messages are an implementation of the Hayes extended result code set. This ATX series of commands can be used if the communications package used recognizes them.

The Half Card has two recessed modular telephone jacks that are connected electrically in parallel. They are unmarked and may be used interchangeably. This information is now stated clearly in the hardware portion of the user's manual. The effect is the same as that obtained by using a duplex block at the wall connector and feeding the modem from one side and a terminal device from the other.

The Half Card's auto-answer mode is switch selectable. In data-only mode, the modem will respond to all incoming calls. When a single line is shared

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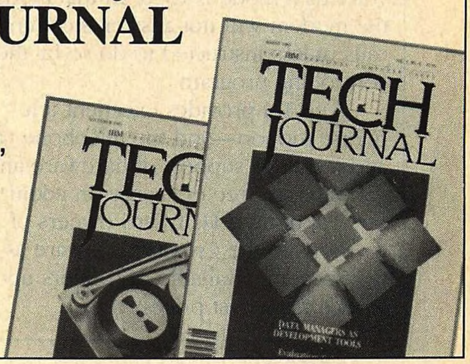

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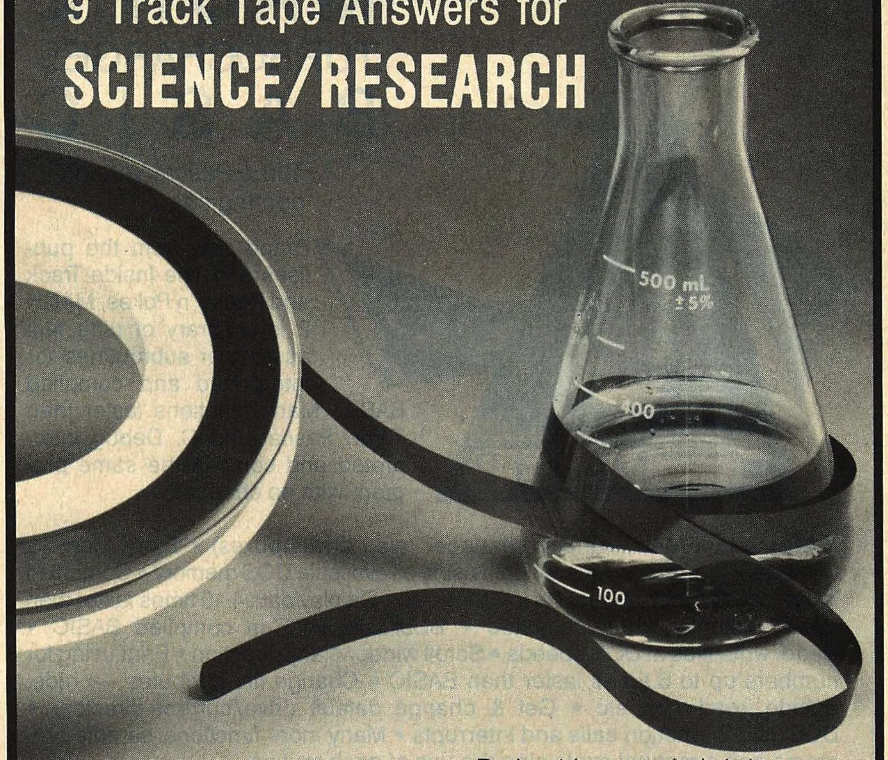

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between voice and data activities, the voice/data mode is used. In this mode, the modem will not answer incoming calls unless instructed to do so by the controlling program.

Ven-Tel provides excellent telephone support—and the telephone call and technical support of hardware and software are free of charge. In addition, Ven-Tel notifies Half Card owners of revisions to the Crosstalk software as they become available, and offers upgrades at modest prices.

Although the PC Modem Half Card is bundled with Crosstalk XVI, it may be used with many other communications programs that adhere to the de facto standard Hayes interface, including Smartcom II, Telios, Relay, and PC-Talk III. None of the other programs uses the COM3 or COM4 port assignments, but that is not the fault of the modem. As a final note, Ven-Tel provides a two-year warranty, not only on this modem, but on all of the modems it sells.

—AUGIE HANSEN

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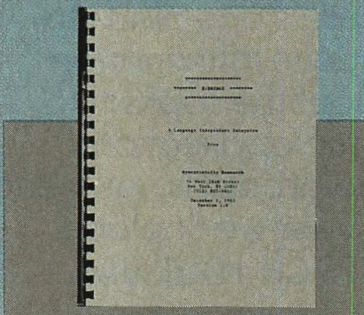

CIRCLE 346 ON READER SERVICE CARD

R:Bridge provides access to R:base 4000 and R:base 5000 data and some R:base commands from one of four languages—APL (APL*Plus/PC), BASIC (Microsoft and IBM), C (Lattice, RUN/C, Microsoft, and C86), and Pascal (Turbo Pascal 2.0 and 3.0). The program works independently of R:base, but R:base is needed for setting up databases and tables. The operation of R:Bridge begins by loading BRIDGE, a memory-resident utility that arranges the access to R:base databases using the language the user has chosen. Programs containing calls to the memory-resident utilities then must be written, compiled, and debugged. (Although the manual says the product is copy protected, the version reviewed, 1.01, is not. The company confirmed this policy change.)

In both C and Turbo Pascal, the CDBS (Coherent Data Base Subsystem) source file must be included in the source program to define the interface to R:Bridge. In C, this file is called CDBS.H; in Turbo Pascal, it is called CDBS.PAS. CDBS defines the interrupt vector that is used to access R:Bridge (60H), the maximum number of bytes that can be contained in a table row (1,530), and the maximum number of active pointers (5). For BASIC, the interface is defined by source code placed at the beginning of the program. An APL work space file containing these definitions is also provided.

R:Bridge includes the following R:base commands: ADD (both single row and block mode), ALLOCATE (block only), CLOSE, CONNECT, DELETE (row and block), DRAW, EDIT, FIND, FORM, GET (row and block),

OPEN, PUT (row and block), RULE, RULER, SELECT (block only), SET, SORT, and WHERE. These commands are identical for each language supported, in addition to being syntactically identical to R:base.

For the user wondering why he should use R:Bridge with R:base 5000, which already has a programming language and a compiler, improved performance will be the deciding factor. (R:base 4000 has no internal programming language—question answered.) The faster execution provided by compiled code is attractive compared to that of interpreted database language. Moreover, R:Bridge seems to improve performance considerably. For example, on a PC/XT with a 10MB hard disk and 640KB RAM, and using DOS 2.1, running a program to open a database and execute the command

```
SELECT ALL FROM <table> SORTED
  BY <key>WHERE <field>
  CONTAINS <value>
```

for a 2,100-record table took 27 seconds using compiled Turbo Pascal and 26 seconds in Lattice C. The same command took 37 seconds with a small R:base interpreted program (and nearly the same for a compiled R:base program). Thus performance is improved by approximately 27 percent.

The BRIDGE utility takes up a hefty 155KB of RAM, but this is offset by the increased functionality and decreased size of the programs that use R:Bridge. Also note that BRIDGE erases itself from memory when the DOS EXIT command is entered at the primary level COMMAND.COM prompt. (SideKick was resident throughout the tests with no detectable negative effects.)

The quality of the program is matched in the documentation. The manual is about 150 pages of clearly written text, organized into three major sections. The first section is devoted to explanations of the more-than-adequate sample programs provided in the package, broken into subsections for each language. One caveat in this section: the CDBS header file under BASIC contains 21 lines of code that are not explained, except for two comment lines that indicate that the code finds the BASIC interface in memory and sets up the CALLing interface. The second section (the user's guide) demonstrates how to develop programs. The functional reference explains the function calls supported by R:Bridge. Users at all familiar with one of the supported languages should have no problems using this utility.

R:Bridge will run on a dual-floppy-disk system, but a hard disk is recommended—it took 18 seconds to load the BRIDGE from a floppy disk. The user also will need one of the supported language products, R:base 4000 or R:base 5000, DOS 2.0 or later, and 256KB of RAM (384KB for APL). R:Bridge is a welcome tool for users looking for improved performance or added flexibility when working with R:base.

—TONY LIMA

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CIRCLE 344 ON READER SERVICE CARD

The great number of statistical programs available for the PC seem to be written either by statisticians with little programming knowledge (powerful, but difficult to use) or by programmers with little knowledge of statistics (user-friendly, but not very powerful). PowerStat is a welcome exception: it is an extremely powerful program with a good user interface.

PowerStat performs many basic statistical functions, including mean, standard deviation, quartiles, and percentiles. It can display and print stem and leaf diagrams, scatter plots, histograms, and box plots, although it provides character graphics only. Regression analyses possible include step-wise, all-possible, Mallows' C_p, regression analysis of variance (ANOVA), residual analysis, and type I and II sums of squares. Rotation, principle components, and factor analysis can be performed with multivariate data and for counted data X^2 and G^2. Expected frequencies, log-linear models, cross-tabulation, and contingency tables are available.

The program's analysis-of-variance capability is particularly impressive, and one of its most useful features. It uses SAS syntax and will be familiar to users of that mainframe package. PowerStat can handle almost any analysis, balanced or unbalanced, with as many as 10 factors; it allows complete flexibility in specifying the model used in the analysis. Repeated measures, Latin squares, unequal Ns, and nested or incomplete designs are all handled with great aplomb. Types I through IV sums of squares can be calculated.

All of PowerStat's statistical procedures manage missing data automatically. The product's error handling is excellent—the straightforward error messages enable the user to determine and correct problems easily. In addition, its context-sensitive help facility is available during most operations.

PowerStat is modular/hierarchical in structure. It has three main modules, one each for data sets, user programs, and statistical procedures. The contents of each module are arranged hierarchically: data sets are contained within data libraries, user programs within program libraries, and so on.

The data set is the basic unit of data in PowerStat. Within a set, data are arranged in a spreadsheet-like manner, with columns corresponding to variables and rows to records. A data set can contain 150 variables (numeric and string); the number of records is limited only by storage. A set is created in one of three ways: from keyboard input, from the import of a text file, or by manipulation of an existing data set. All three require user-written programs. Data sets can be modified with PowerStat's data set editor. Because the format of these sets is similar to that in SAS, SPSS, and BMDP mainframe packages, moving a file from SAS to PowerStat requires only a few changes to control codes with a text editor.

Available only in the program module (user-defined statistical functions are not supported) is PowerStat's flexible, BASIC-like programming language. Designed to create and modify data sets, the language is easy to use for simple tasks. For example, a three-line program can import data from either a text file or the keyboard. The language includes if...then...else statements and iterative loops, as well as trigonometric and logarithmic functions. Programs can be up to 500 lines long, which allows for complex data transformations and selection of data subsets based upon certain criteria. A built-in program editor is included with the program.

PowerStat's statistical functions are accessed via the menu-driven procedures module. When a procedure is selected, the user is prompted for data about various aspects of the analysis. Some information is optional, such as the number of decimal places in the result and redirection of output to printer or disk. Other information must always be supplied, for example, the variables to be compared and the model for an analysis of variance.

At about 500 pages, the PowerStat manual is clear and well organized, with many examples. It does not pretend to be a text book on statistics and, where necessary, refers the reader to technical papers and books for further reading. Throughout, the manual makes note of certain procedures, such as multifactor analysis of variance, that require some statistics knowledge to be performed properly with PowerStat.

In testing, PowerStat was used to run several statistical routines. The results were compared with some that were published in statistical text books as well as results produced by mainframe statistical programs. In all cases, PowerStat's results were found to be completely accurate. The program's speed also was tested. Running on a PC equipped with an 8087 coprocessor, PowerStat took only 15 minutes to run a 3-factor, unbalanced, 300-score analysis of variance. The SAS package running on an IBM 3031 mainframe required almost 5 minutes of CPU time to run the same test.

PowerStat can be run on a system with either two 360KB floppy-disk drives or one hard-disk and one floppy-disk drive. It requires 256KB of memory and DOS 2.0 or later. The program does not require an 8087/287 numeric coprocessor, but will used one if present. PowerStat is not copy protected.

The program does have some minor problems. For example, it emits a noise when a command key is pressed *correctly*. Not only is this annoying, but the sound is one generally associated with an incorrect key press. Also, the data and program editor could be improved. Finally, the ability to run batch processes would allow the program to run a number of complicated analyses unattended. But even as it stands PowerStat, is an excellent program, with many functions usually found only in mainframe packages.

—PETER AITKEN

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Multiple Line Types in Layer	299	N/A
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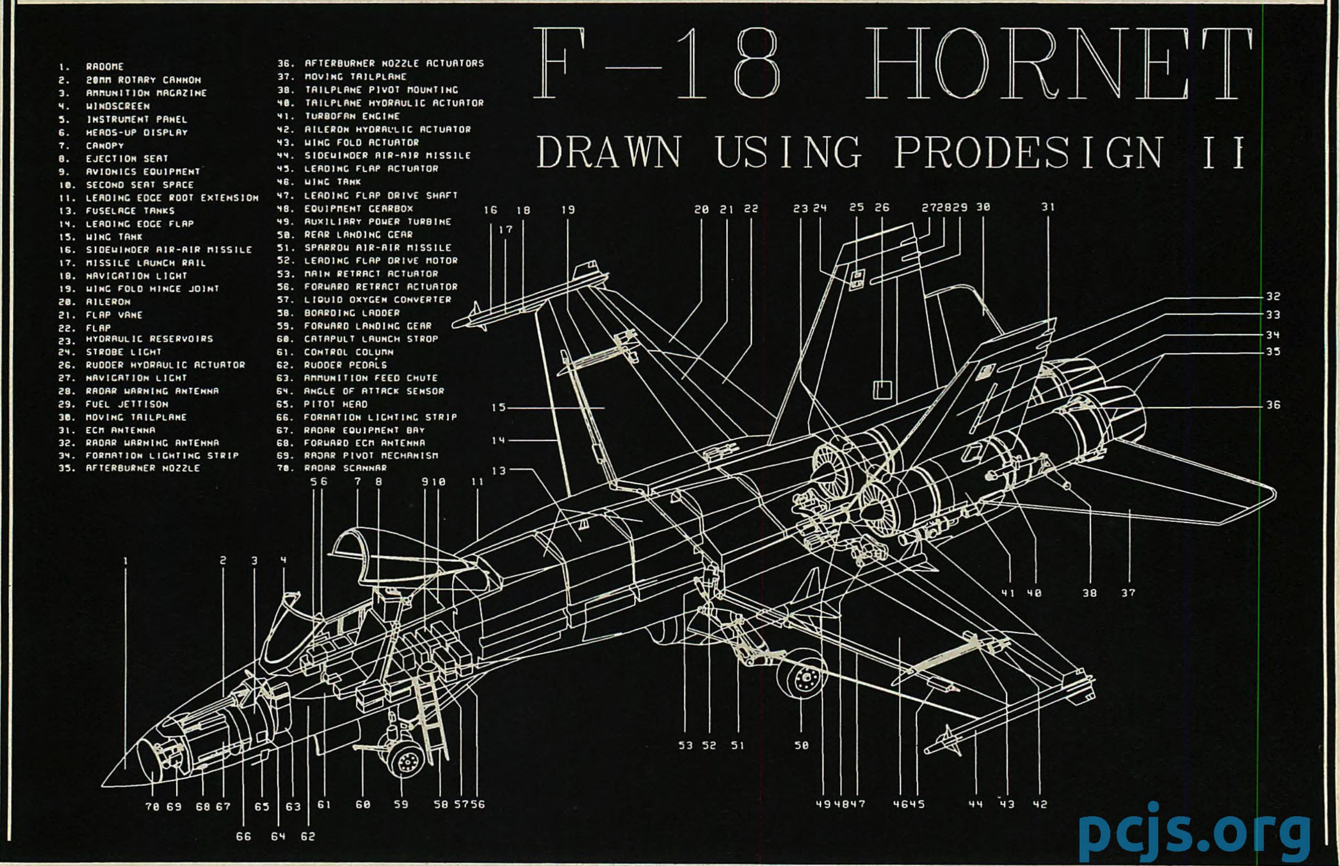
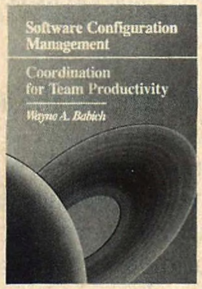


Coordinating Software Teams

At last, a book addresses the issue of structuring communication and development coordination among software engineers.

Software Configuration Management—Coordination for Team Productivity
Wayne Babich (Addison-Wesley Publishing Company, Reading, MA 1986)
162 pages, paper, $18.95



It comes as a slow, hard-earned lesson for software engineers that good programming and design are not enough to succeed. Even brilliant individual efforts are not enough to ensure a productive software project if it involves more than one person. Communication and coordination among members is as important as individual effort; often it is *more* important.

The term *configuration management*, applied to software, embraces techniques for structuring communication and coordination among software engineers who are developing a program together. Successfully applied, configuration management reduces the confusion, backtracking, and loss of work that can occur when programmers unwittingly collide with each other while testing and modifying software. Wayne Babich's *Software Configuration Management—Coordination for Team Productivity* is the first book on this subject in the popular computing press.

Babich introduces the problems addressed by configuration management systems simply, clearly, and entertainingly. Most revolve around programmers trying to answer the question "Which program is this?" The question pops up more frequently as "This worked yesterday. What happened?" or "Where is the fix I put in last week?" or "Was that bug fixed in this copy, too?" The coordination breakdowns that give rise to such questions are productivity-killers for software teams. In extreme cases, configuration management problems can bring a project with an excellent staff to a standstill.

The notion of a *baseline* is central to configuration management. A project's baseline is a consistent, stable set of software modules that represent the project's current state of development. One goal for developers is to always ensure the *consistency* of the baseline. Copying the revised source of a module into the baseline without copying its object file, for example, is a mistake that destroys consistency and can take hours, even days, to unravel. Babich discusses procedures such as UNIX **make** that help eliminate consistency problems. Simultaneous updates—situations in which two programmers copy, change, and replace the same module, losing one set of changes in the process—can be avoided by *checking out*, or *locking*, modules to allow work by only one person at a time.

The author offers the indisputable rule that "multiple copies inevitably diverge." The double maintenance problems that can arise from duplicated code are all too familiar: bugs get fixed in one or two copies of a subroutine but not in all of them, or two programmers extend two copies in irreconcilably different ways. Tools such as the UNIX Source Code Control System (SCCS) and Revision Control System (RCS) reduce the need for multiple copies. Storing just the differences, or *deltas*, between modules with large sections in common, reduces storage space requirements.

Babich devotes an insightful chapter to the design of interfaces. He points out that well-designed, "information-hiding" interfaces can greatly reduce the occurrence of double maintenance problems by reducing the need to replicate similar code in many modules. Software archiving systems such as SCCS and RCS also support the maintenance of compact, complete module histories, allowing the reconstruction of any previous revision of a module as well as serving as a repository for the most current versions.

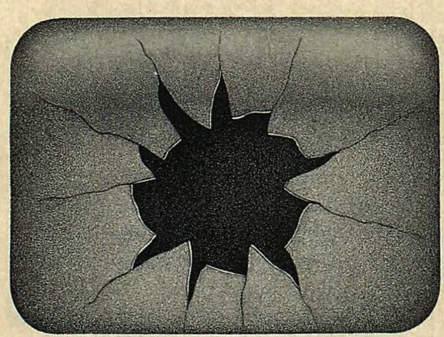
In order to analyze the behavior of a software system, the developer must have precise, detailed information on its *derivation*: which versions of what modules were linked to form the executable, what header or include files they were compiled with, which options were in force when they were compiled and linked, and so on. Babich underscores the importance of collecting this often-neglected information. Complete derivation details are useful not only in understanding a program's behavior ("Which program is this and why doesn't it work right?"), but also in reproducing an older version of a program for diagnostic purposes.

Babich follows a lucid, abstract discussion of problems and remedies with concrete descriptions and critiques of the configuration management resources in the UNIX and Ada environments. He concludes with an account of how a 50-person team established configuration management procedures on a large software project. This case history, along with comments on the practical requirements and difficulties of configuration management throughout, provides prescriptive, directly applicable advice for software engineers mounting projects of any scale.

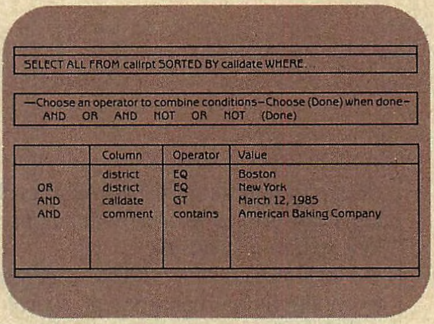
In a decade in which businesses are obsessed with increasing productivity, *Software Configuration Management* is valuable reading for any programmer or software manager. The book's clear presentation of theory, rationale, and practice makes it as useful to the engineer who has grappled with configuration management problems for years as it is to the novice who still puzzles over why so much goes wrong when a group develops software.

—RICHARD M. FOARD

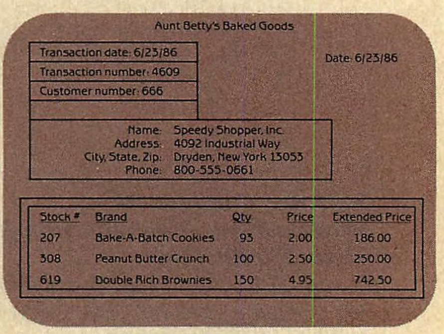
NOW. POWERFUL WITHOUT POWE



A typical DBMS user's screen, after the 497th line of code.



An R:BASE System V Prompt-By-Example (PBE) screen. With PBE's query capabilities, you can retrieve just the information you need. Without programming.



A data entry screen designed without programming, using Forms EXPRESS.

With most database management software for the IBM PC family and compatibles, you're quickly confronted with a painful reality: the only way to make your package live up to its promise is to learn its programming language. Which can take months. Then you have to write the code, line after frustrating line.

But now, there's R:BASE™ System V. And for the first time, you can quickly create programs that automate your most important data management tasks. Without programming.

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Then you can use Forms EXPRESS to create customized data entry forms. The forms you create can load data into five different tables, linked in One-To-Many relationships. You can also include scrolling regions, custom borders, and custom colors, all without programming.

And with Reports EXPRESS, you can design reports exactly the way you want. And see what they'll look like, right on the screen. To see how complex your reports can be, take a close look at the example at the end of this page.

Finally, you can tie it all together with Application EXPRESS. First, you design your own multi-level system of menus. Your first menu level might look like this:

```
Aunt Betty's Sales Reporting System
    (1) Enter Sales Data
    (2) Edit Sales Data
    (3) Print Daily Sales Report
    (4) File Processing
    (5) Exit
```

For each menu choice, you assign an action. For example, to define menu choice #3, choose the action "PRINT," select the report you just created in Reports EXPRESS, and specify the appropriate data sorting and selection criteria. Then Application EXPRESS automatically writes the program code.

Which means you've just created a very sophisticated program to deliver the full power of your DBMS. And you've done it all without learning how to program. From this point on, every time you want to run a report, all you do is choose item #3. With one simple keystroke, you've got it.

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If you're an experienced programmer, you can use R:BASE System V to tackle the most demanding applications. You can use Application EXPRESS to create prototypes faster than with any other microcomputer-based DBMS.

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DBMS PROGRAMS
RFUL DBMS PAIN.

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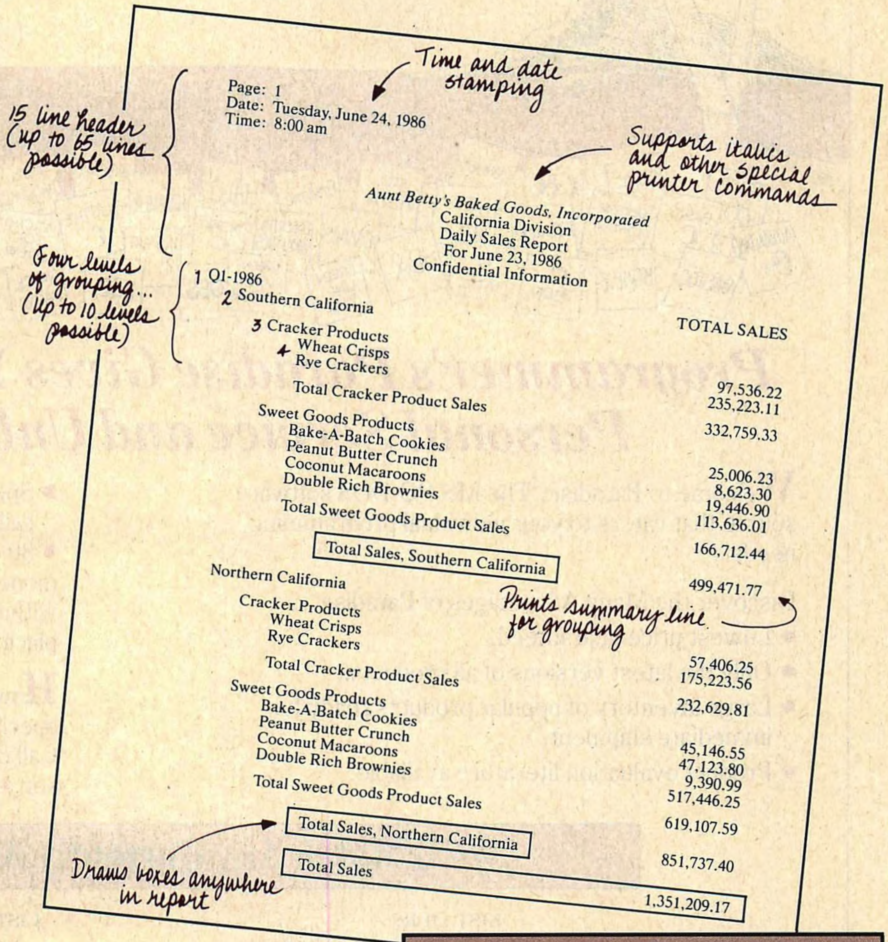

15 line header (up to 65 lines possible)
Time and date stamping
Supports italics and other special printer commands
Four levels of grouping... (up to 10 levels possible)
Prints summary line for grouping
Draws boxes anywhere in report

Page: 1
Date: Tuesday, June 24, 1986
Time: 8:00 am

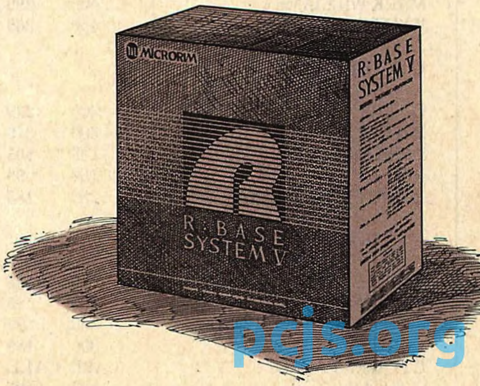
Aunt Betty's Baked Goods, Incorporated
California Division
Daily Sales Report
For June 23, 1986
Confidential Information

TOTAL SALES

1 Q1-1986
2 Southern California
3 Cracker Products
4 Wheat Crisps
Rye Crackers
Total Cracker Product Sales
Sweet Goods Products
Bake-A-Batch Cookies
Peanut Butter Crunch
Coconut Macaroons
Double Rich Brownies
Total Sweet Goods Product Sales
Total Sales, Southern California
Northern California
Cracker Products
Wheat Crisps
Rye Crackers
Total Cracker Product Sales
Sweet Goods Products
Bake-A-Batch Cookies
Peanut Butter Crunch
Coconut Macaroons
Double Rich Brownies
Total Sweet Goods Product Sales
Total Sales, Northern California
Total Sales

97,536.22
235,223.11
332,759.33
25,006.23
8,623.30
19,446.90
113,636.01
166,712.44
499,471.77
57,406.25
175,223.56
232,629.81
45,146.55
47,123.80
9,390.99
517,446.25
619,107.59
851,737.40
1,351,209.17

A program to print this report daily, with a one-keystroke menu pick, was developed without programming using R:BASE System V's EXPRESS Technology. Whether you know how to program or not, R:BASE System V is the shortest distance to your data management solution.



NEW R:BASE SYSTEM V
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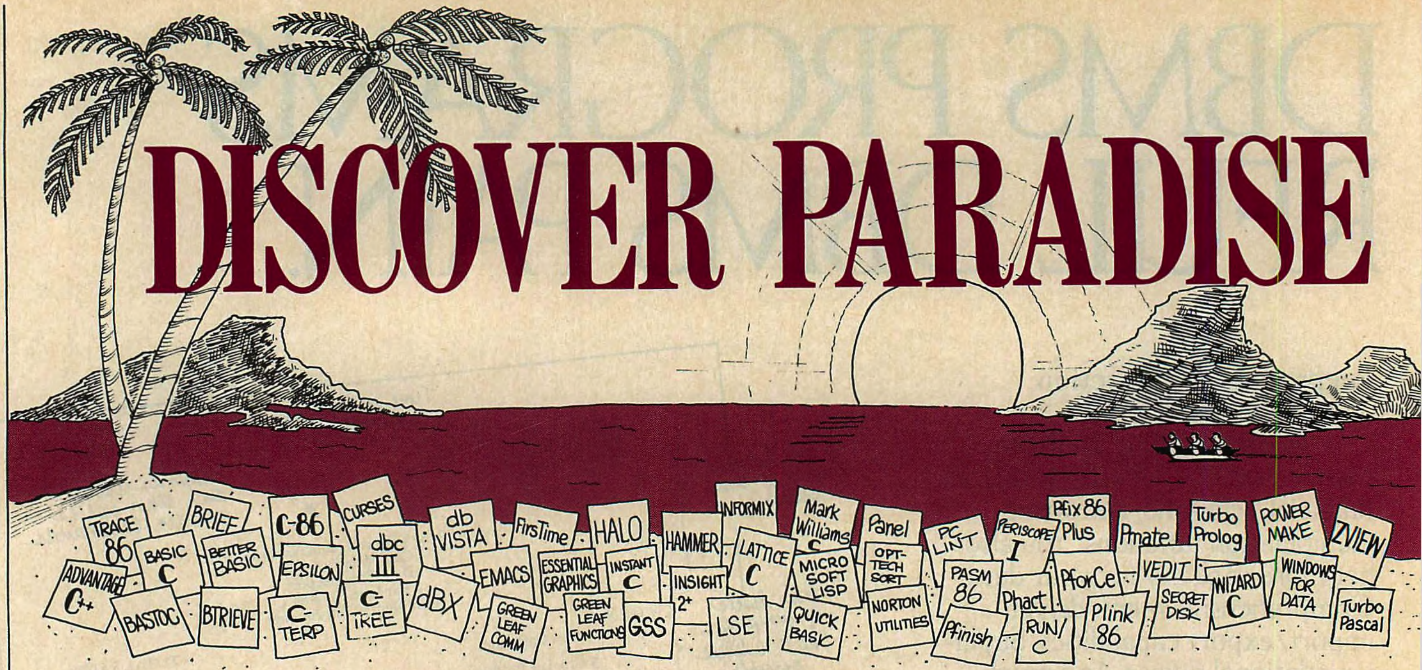

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PASCAL TOOLS I	125	105
PASCAL TOOLS II	100	84
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	LIST	OURS
ALICE	95	69
FIRSTIME	75	69
FLASH UP WINDOWS	75	69
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The Virtues of Patience

Quick-fix legislation to combat unauthorized use of software may be worse than the problem.

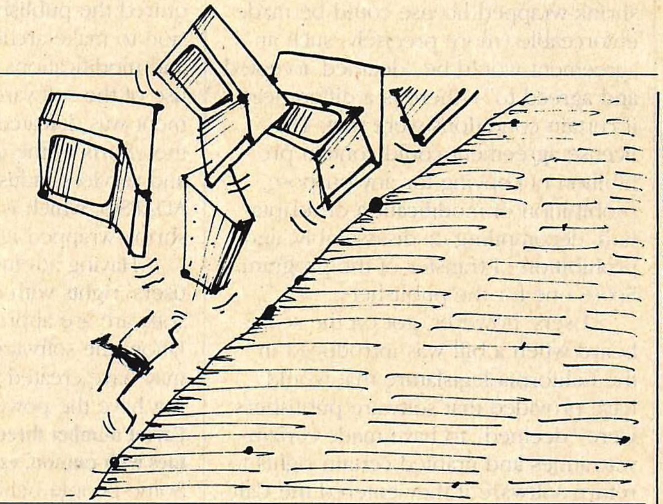

ILLUSTRATION • MACIEK ALBRECHT

People acquire computers for speed. Producers of computer hardware and software recognize that speed is a significant factor in marketing. It is, therefore, not surprising that many people in the computer industry are frustrated by the slow pace of development of case law in their field.

A price must be paid, however, for quick legislative answers to difficult questions. A review of several recent attempts to solve problems with statutes should illustrate the dangers of quick-fix legislation. An overview of the differences between common law and statutory law will be helpful here.

Common law is built case by case. Each decision influences, but does not control, later decisions. Judges examine what other judges have done, but the parties to a suit can attempt to persuade the judge that the earlier decision is inapplicable because of distinguishing factors in the pending case.

This process has its drawbacks: until an issue is raised in a particular case, definitive guidance on the issue is not available; there is no guarantee that issues will be raised in an orderly fashion; private litigants—concerned about winning their own case, not the precedent they may be setting—control the choice of issues to be presented.

As a result, many cases are needed to build a coherent theory of a given area of the law. The process may be significantly slowed by a single, bad decision. This is somewhat like having a pair of shoes custom made by separate shoemakers for the left and right sides of each shoe; they may finish the sides before anyone gets around to deciding the size or shape of the sole.

If the development of common law is like the creation of custom-made shoes, then statutes are off-the-rack. Someone perceives a problem, attracts the attention of a legislature, proposes a solution, and gets enough votes to adopt it. Thereafter, everyone subject to that statutory shoe has to wear it whether it fits or not. This approach does eliminate the need to await a dispute between parties willing to spend the money to get a judicial answer, but it also reduces the system's ability to adopt a measured response, and it may substitute political power for reason.

Further problems are presented when a statutory remedy must be enforced in court: in construing a statute, the court attempts to determine how the legislature meant the law to apply to the pending case. Sometimes that is easy, but sometimes it involves scrutiny not only of what the statute says, but also of what words were chosen, where commas were placed, and what was left unsaid. Listed below are several caveats for those who would solve complicated problems with simple laws.

Caveat number one: legislatures are busy. A fundamental problem in the marketing of microcomputer software is the risk of mass piracy. Some lawyers perceive certain areas of the copyright law (a statute) to be ambiguous in their protection of software against at least some forms of *unauthorized* use. The copyright law had undergone massive study leading to revisions in 1976 and had been amended in the computer area again in 1980—politically, the chances of an additional round of fine-tuning are remote. Having grabbed a legislature's attention and shepherded a law into existence, getting the lawmakers to revisit its decision in the near future is difficult. (The one federal statute that is frequently amended, and frequently subject to technical and conforming amendments, is the tax code. Few would consider that a good model for curative legislation.) Yet, a problem clearly still exists despite the fact that the recent copyright act revisions were among the most carefully studied pieces of legislation imaginable.

Caveat number two: political power is fickle. A trouble spot in copyright law is the first-sale doctrine, which provides that once a copyright owner has sold a copy of his work (the "first sale"), he no longer controls that copy—he can prevent the purchaser from copying it, but he cannot prevent the purchaser from reselling, lending, renting, or otherwise disposing of it. To avoid the trouble spot of the first sale doctrine, many companies adopted the shrink-wrapped license agreement instead of selling their software (see "License to Sell," Legal Brief, March 1986, p. 189). A problem remained, however: obtaining signed license agreements from users generally was not possible. Years passed and no case was brought before the courts that posed the issue of the en-

forceability of shrink-wrapped licenses. (One reason may be the serious question of whether such a suit actually could be won.)

Several legislatures were convinced to examine the situation. The Illinois legislature was persuaded that the question of enforceability needed an answer, and the Illinois "Software License Enforcement Act" was passed, effective July 1, 1986. That statute, which has not yet been tested in court, stated that a shrink-wrapped license could be made enforceable (more precisely, such an agreement would be "deemed accepted and agreed to"—there is a difference) if certain conditions were met. The license agreement could contain prohibition of copying for any purpose, prohibition of modification or adaptation, decompiling or disassembly, and prohibition of transfer of the program. Score one for the publishers.

Users, however, got on the scoreboard when a bill was introduced in the California legislature that would have provided that software publishers were "deemed" to have made certain warranties and granted certain rights to return software if they entered the California market. The bill was not passed, but it was a lesson for the industry.

That lesson was repeated in Illinois, where a proposal to amend the Software License Enforcement Act would have provided similar users' rights. The amendment would have permitted the return of software if the purchaser did not accept the license terms (even if the package had been opened and the software used) within a "reasonable time." The shipping costs also would be borne by the publisher. The amendment also would have required the publisher to grant permission to make archival copies of software and modifications that are steps in the use of the software. The Illinois amendment was defeated, in part because of the efforts of the computer software and services industry association, ADAPSO, which is now opposed to all shrink-wrapped legislation.

Having advanced the notion that users' rights with respect to computer software are appropriate topics of legislation, the software publishing industry may have created a monster that it does not have the power to control.

Caveat number three: when hunting mosquitoes with cannon, expect innocent victims. Some people believe that the primary danger presented by the first-sale doctrine is that software rental might proliferate, which will provide easy access to software for the purpose of unlawful copying. They have convinced a representative to introduce the "Computer Software Rental Act of 1986" into Congress, which would remove software from the coverage of the first-sale doctrine. The proposed bill is subject to criticism even accepting the idea that restricting the use of lawfully acquired copy of a program is legitimate: the House bill would effectively inhibit the short-term rental of computers in the process. At times, a computer is needed away from the office. Assuming that the renter does not want to travel with software (or that the license agreement prohibits the travel), he or she is faced with buying an extra set of software or suffering the risks of traveling with the original software (or making a prohibited copy and mailing it ahead).

Caveat number four: it's hard to think of everything. A case can made for the proposed Computer Software Rental Act: situations undoubtedly exist in which software rental is no more than a guise for the true purpose of permitting unauthorized copying. The author of the bill argued, "One hardly wishes to learn a word processing or financial management program only to return it to a rental store a few days later. By the same token, productivity, creativity and educational software is used over a longer period of time than would be practical when one is renting." This does not address the possibility that rental software might fill a legitimate need in conjunction with rented hardware or that renting an adventure game for a week might be a rational act even without an intent to copy unlawfully. Of potentially greater consequence, the bill is directed solely to commercial rental. Traditional libraries, following the trend from lending books to records to movies, are now becoming interested in lending software. If a problem is presented by the availability of software for a fee, it is equally presented by the availability of software for *no* fee. The Software Publisher's Association, which urged the introduction of the bill, hopes to have such issues addressed in the committee process.

It is tempting, when faced with a problem, to say "there ought to be a law." The difficulty arises in making sure that the statutory cure is not worse than the ailment.

Max Stul Oppenheimer, PC, is a partner in the law firm of Venable, Baetjer & Howard, located in Baltimore, Maryland.

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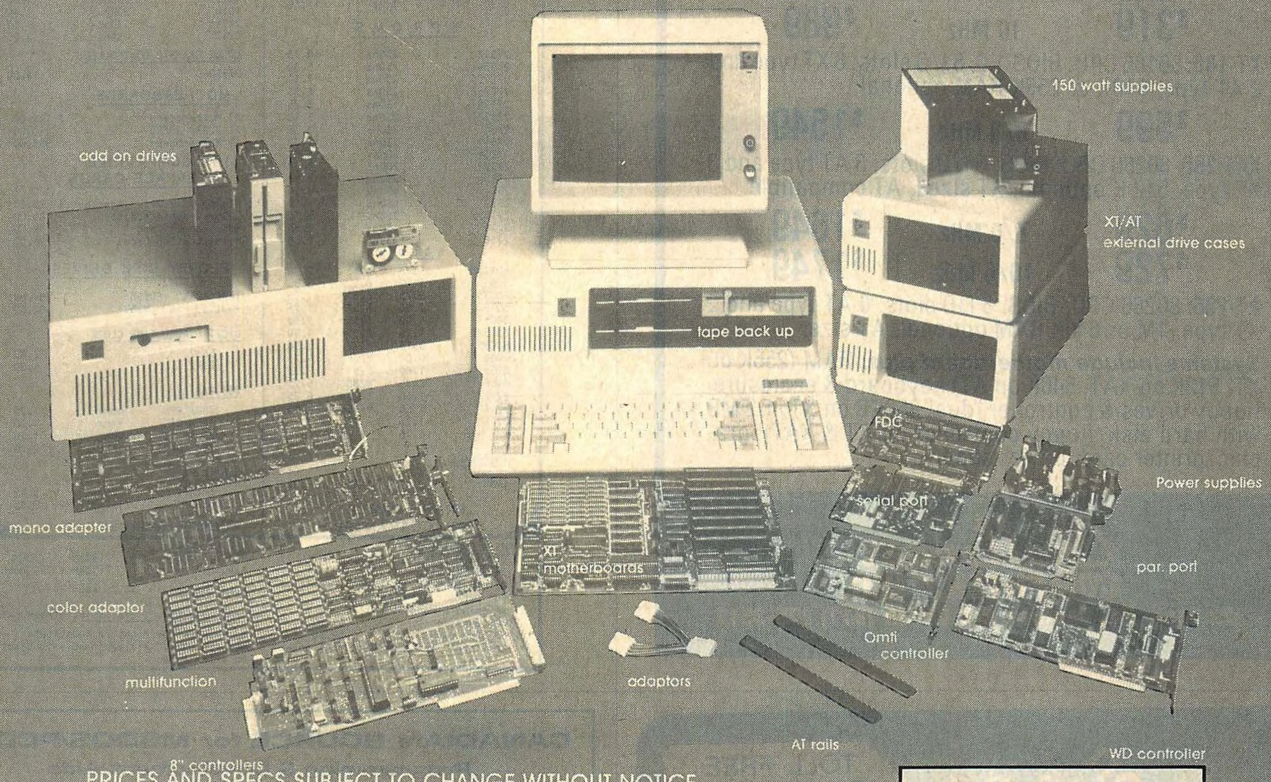

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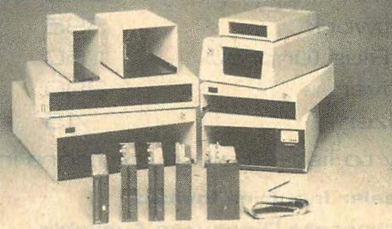

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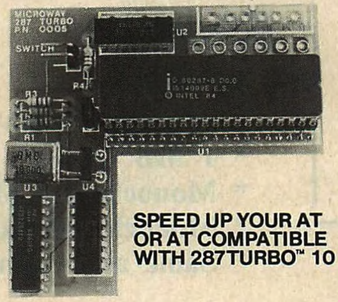

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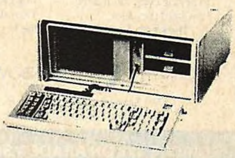

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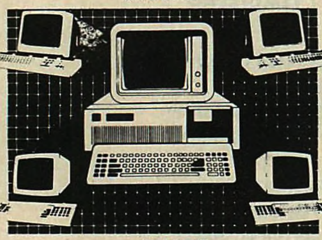

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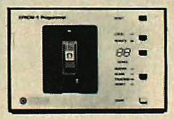

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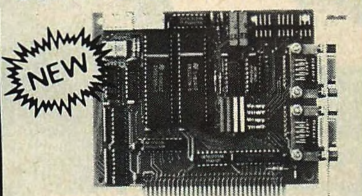

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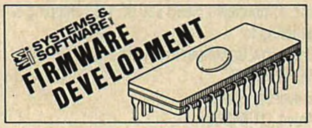

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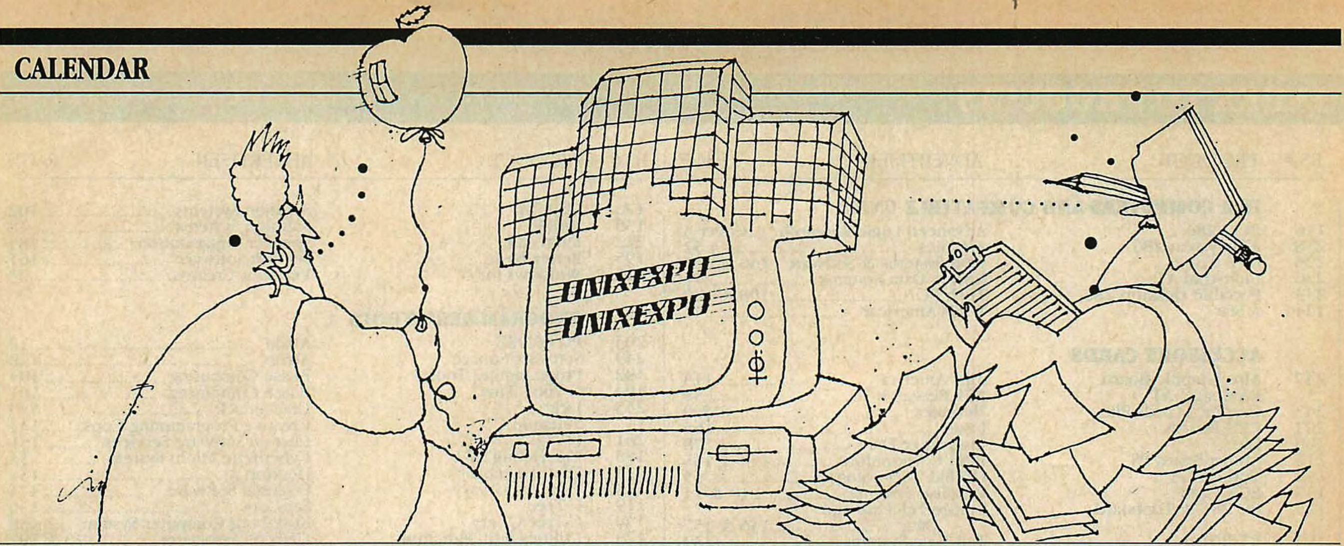

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October 25-26
Information Systems Education Conference (ISECON) '86
Atlanta, GA
Sponsor: Data Processing Management Association Education Foundation
Contact: Dr. Kathy Brittain White, University of North Carolina, Information Systems, Greensboro, NC 27412; 919/379-5666

October 26-November 3
INDIA '86
Bombay, India
Sponsor: Industrial and Trade Fairs International
Contact: Mr. Hasu Ramji, Industrial and Trade Fairs Limited, Oriel House, 26 The Quadrant, Richmond upon Thames, TW9 1DL, UK; 01-940 6065

October 27-28
Pacific Northwest Computer Graphics Conference
Eugene, OR
Contact: Conference Manager, University of Oregon Continuation Center, 1553 Moss Street, Eugene, OR 97403; 503/686-3537

October 27-30
International Conference on Computer Languages
Miami Beach, FL
Sponsor: IEEE-CS
Contact: Joseph Urban, University of S.W. Louisiana, Center for Advanced Computer Studies, Lafayette, LA 70504; 318/231-6304

October 28-30
Introduction to Network Architecture
Atlanta, GA
Sponsor: Georgia Institute of Technology
Contact: Deidre Mercer, Department of Continuing Education, Georgia Institute of Technology, Atlanta, GA 30332-0385; 404/894-2547

NOVEMBER

November 2-6
Fall Joint Computer Conference
Dallas, TX
Sponsor: ACM and IEEE-CS
Contact: Roberta Bukar, ACM Headquarters, 11 W. 42nd Street, New York, NY, 10036; 212/869-7440

November 10-14
COMDEX/Fall '86
Las Vegas, NV
Sponsor: Interface Group
Contact: The Interface Group, Inc., 300 First Avenue, Needham, MA 02194; 800/325-3330

November 17-18
Computer Networking Symposium
Washington, DC
Sponsor: IEEE
Contact: Computer Networking Symposium, 1730 Massachusetts Avenue, NW, Washington, DC 20036-1903; 202/371-0101

November 18-20
LOCALNET '86
San Francisco, CA
Sponsor: Online International
Contact: Online International, 989 Avenue of the Americas, New York, NY 10018-5485; 212/279-8890

November 18-21
Wescon '86
Anaheim, CA
Sponsors: IEEE/Electronics Representatives Association
Contact: Dale Litherland, Director of Education, Electronic Conventions Management, 8110 Airport Blvd., Los Angeles, CA 90045; 213/772-2965

November 19-21
Ada Expo '86
Charleston, WV
Sponsor: The Software Valley Corporation
Contact: Becca Essman, Exposition Manager, P.O. Box 868, Frederick, MD 21701; 301/662-9400

DECEMBER

December 2-4
Protecting Intellectual Property
Washington, DC
Sponsor: American Institute of Aeronautics and Astronautics and The U.S. Department of Defense Computer Institute
Contact: Dr. Joel Levy, General Chairman, ORI, Inc., 1375 Piccard Drive, Rockville, MD 20850

CALLS FOR PAPERS

Deadline: October 31
International Workshop on FORTH and its Applications
Taipei, Republic of China
(October 31-November 2)
Sponsor: The FORTH Interest Group
Contact: FORTH Interest Group, P.O. Box 8231, San Jose, CA 95155; 408/277-0668

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114	129	144	159	174	189	204	219	234	249	264	279	294	309	324	339	354	369	384	399
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"ADVANCED LOGIC SHIPS AT™ COMPATIBLE WITH AN XT™ CLONE PRICE"

Computer Retail News
Monday, July 7, 1986

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SMARTER DESIGN!

Like all products in the ALR line, the PC2/286 is born with enhancements and the latest technology available. THE NEXT GENERATION has speed and power equal to that of the AT™, is as small as the XT™, but the complete system (including graphics video card and high resolution monitor) costs less than both! How? Smarter design! Like we've always said ALR doesn't design products without improving them beyond what our competition offers.

Smarter design, as well as being superior, is less expensive to manufacture so you pay less.

We've incorporated all the knowledge that the past successes and failures of big manufacturers have afforded and used it to make a better product.

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- 1.2 MB floppy disk drive
- 1 serial, 1 parallel printer port
- Hercules compatible Monographics Adapter, AT compatible floppy disk controller on board
- 130 Watt UL/CSA Power Supply
- Clock/Calendar Battery Backup
- AT style 83 Keyboard
- High resolution Monochrome Monitor

PC2e/10MHz

- 10 MHz 80286-10 CPU 8-10 MHz switchable
- 20 MB/30 MB 40ms high speed hard disk
- 1.2 MB high density floppy disk drive
- 16 Bit high speed hard disk controller
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